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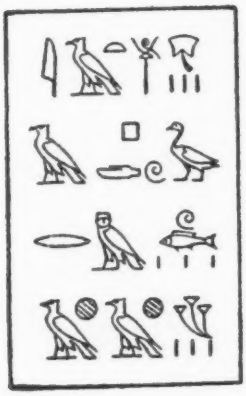
THE JOURNAL OF WILDLIFE MANAGEMENT



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THE JOURNAL OF WILDLIFE MANAGEMENT

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A METHOD FOR DETERMINING EXTENT OF RODENT DENS

R. Frank Hedges

During the process of investigating the burrowing activities of kangaroo rats in dams and other earth structures, a method of determining the extent of the dens was devised that may be of use to other investigators.

The excavation of dens is a time-consuming operation and becomes impractical when information is required on a large number of dens. Then, it is necessary to supplement data gathered through digging by that obtained in a more rapid manner. To this end, the following method was employed with excellent results. The procedure is a modification of the old method of using the exhaust of an automobile to kill burrowing animals. However, we were not interested in killing the rodents, nor in forcing them to leave their dens. The object was to determine the number and position of entrances and the extent of the burrows. This was done by forcing heavy smoke into one opening and noting its issuance from others.

The procedure is as follows: A garden hose, fifty feet long, is attached to the exhaust pipe of an automobile for the purpose of carrying the smoke to the rodent burrows. The accompanying diagram (Fig. 1) illustrates the manner in which the adapter is made for attaching the hose to the exhaust pipe. The hose

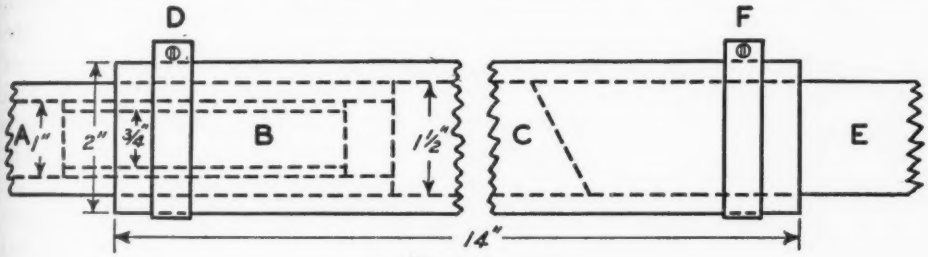

Figure 1.

(A) should be 1-inch inside diameter. A 4-inch piece of ¾ size iron pipe (B) is inserted in the end of the garden hose to prevent it from collapsing under the clamp. A 14-inch piece of radiator connection hose (C) of 1½-inch inside diameter is slipped over the end of the garden hose (A) a distance of 4 inches and secured with a hose connection clamp (D). The free end of the hose (C) is slipped over the end of the exhaust pipe (E) a distance of 4 inches and secured with a second clamp (F). The 14-inch length of connection hose is used to provide sufficient flexibility in the adapter to prevent it from breaking. The adapter is strong enough to permit the fifty-foot hose to be dragged short

distances behind the automobile during changes of location.

Since the normal exhaust of an automobile does not provide sufficient smoke for this purpose, it is necessary to use a smoke-producing agent which in this case was kerosene. This is accomplished by disconnecting the windsheld wiper tube from the coupling on the intake manifold, replacing it with four feet of similar tubing, and, after the motor is started, submerging the free end of the tube in a container of kerosene. The tube is removed from the kerosene after 3 or 4 seconds and is not submerged again until the volume of smoke diminishes. Because of the possibility of flooding the motor, care must be exercised with respect to the quantity of kerosene admitted.

The kerosene flows into the intake manifold and enters the compression chambers with the motor fuel. It is not harmful to the motor unless used for long periods without intermission, and may have a beneficial effect in removing accumulations of carbon from the pistons and valves. One gallon of kerosene is sufficient for a day's work.

While the car motor is running and producing copious smoke, as a result of the kerosene, the free end of the hose is inserted in one of the entrances of the den to be investigated. Since the smoke is driven from the hose with sufficient pressure to force it through the connecting burrows, all openings of the den will be identified by the smoke issuing from them. The investigator may thus determine the extent of the den and the number of entrances that are connected in one system. The work is most efficiently done by two men, one to operate the car and record the data, while the other manipulates the hose and makes the observations.

The details of this method may be adjusted to apply to any car that is available. On an automobile that does not have an opening to the intake manifold, the kerosene may be added through the air intake of the carburetor. If hose of the size mentioned is not available, a smaller size may be used by adding a bushing of the proper thickness to fit the connection hose.

This method was used in investigating the burrows of only banner-tailed (*Dipodomys spectabilis*) and Ord (*D. ordii*) kangaroo rats, but it is believed that it will work as well on the burrows of other rodents. It has a practical application in determining whether or not rodent burrows extend through earthen dams and other water holding or controlling structures.

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SOME PLANTS VALUABLE TO QUAIL IN SOUTHWESTERN TEXAS

Valgene W. Lehmann and Herbert Ward

Quail welfare is greatly dependent on vegetation because plants furnish the major supply of both cover and food. The exact relationships of all southwestern Texas plants to quail are, of course, unknown, but the value of some of them, however, is known and is herein discussed.

The area of the present study (Fig. 1) is that portion of southwestern Texas commonly referred to as the "brush country," or Rio Grande Plains. Ward has lived and studied in this territory for more than 25 years; Lehmann has worked there periodically since 1934. Statements concerning food habits are based on the examination of 565 crops of the Texas bob-white (*Colinus virginianus texanus*), and 32 of the chestnut-bellied scaled quail (*Callipepla squamata castanogastris*). This material was collected principally by state game wardens Chas. G. Jones, A. E. Hitzfelder, M. E. Williams, John Crow, Jesse Craft, John Hearn, W. A. Truesdel, B. Martin, Phillip Trammel, and D. R. Murchison over the period beginning December 1, 1934 and ending January 16, 1935. Identification of puzzling food items was by the Section of Food Habits Research, Division of Wildlife Research, United States Biological Survey.

Some Plants Valuable to Bob-Whites

Two types of habitat are especially favorable to the Texas bob-white: (1) sandy well-drained grassland with fairly open woody cover, and (2) farming country where cultivation is not too clean. In these habitats food is usually much more abundant than elsewhere. Except as specified in Table 1, seeds of the plants mentioned are the parts

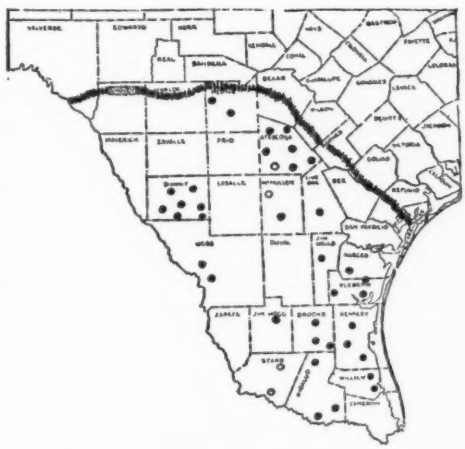

Figure 1. Approximate points where quail crops were obtained.

- ● Bob-whites
- ○ Chestnut-bellied Scaled Quail
- Northern boundary of the Rio Grande Plains, or "Brush Country" (According to Cory, V. L., and Parks, H. B. 1937, Catalogue of the Flora of Texas. Texas Agricultural Experiment Station. Bul. 550).

eaten by the quail. Those of panic grass (*Panicum texanum*), which grows most luxuriantly in corn fields, composed 30.41 per cent of the contents of the 565 stomachs examined. Sorghums, chiefly redtop cane and hegari, contributed 11.27 per cent to the winter diet. Practically all of these grains found in quail

crops appeared to be waste. The doveweeds or goatweeds (especially *Croton capitatus*, *C. punctatus*, and *C. texensis*) supplied 20.12 per cent of the winter food in 1934–1935; these plants reach greatest abundance in sandy grassland and cultivated areas. Wild carrot (*Chaerophyllum*), clover (*Trifolium*), queen's delight (*Stillingia dentata* and *S. linearifolia*), skunk daisy (*Ximenesia encelioides*), and trailing wild bean (*Strophostyles helvola*) also were important; collectively they furnished 10.55 per cent of the winter food. These species also grow best in loose or disturbed soil.

TABLE 1

FIFTEEN IMPORTANT SOURCES OF WINTER FOODS OF SOUTHWESTERN BOB-WHITES

Name of plant		Number of crops containing	Percentage of total contents
Common name	Scientific name		
Panic grass	Panicum texanum	169	30.41
Sorghum (redtop and hegari)	Sorghum sp.	88	11.27
Doveweed, goatweed	Croton capitatus	118	8.92
Doveweed, goatweed	Croton punctatus	62	5.60
Doveweed, goatweed	Croton texensis	25	5.60
Oaks (chiefly live oak)	Quercus virginiana & Q. sp.	25	5.45
Green food (leaves, chiefly wild carrot and clover)	Chaerophyllum sp. and Trifolium sp.	102	3.99
Queen's delight	Stillingia dentata	60	2.15
Skunk daisy	Ximenesia encelioides	50	1.58
Trailing wild bean	Strophostyles helvola	12	1.48
Mesquite	Prosopis glandulosa	75	1.39
Queen's delight	Stillingia linearifolia	28	1.35
Panic grass	Panicum fuscum	25	1.16
Panic grass	Panicum sp.	30	.95
Corn	Zea mays	25	.88

Bob-white food plants that do not appear to be of great general importance, but which are often of appreciable local significance include: the bluebonnet (*Lupinus texensis*), sensitive briar (*Neptunia pubescens*), partridge peas (*Chamaecrista procumbens* and *C. fasciculata*), Johnson grass (*Holcus halepensis*), day flower (*Commelina crispa*), ragweed (*Ambrosia psilostachya*), hog pea (*Galactia canescens* ?), bull grass (*Paspalum debile* and *P. stramineum*), madder (*Richardia brasiliensis*), four-leaf pea (*Galactia grayi*), one-leaf bean (*Rhynchosia americana*), red pea (*Indigofera miniata*), poor-joe (*Diodia teres*), thistle (*Asper* sp.), crow-foot grass (*Chloris sp.*), bristle grass (*Setaria sp.*), wooly ground cherry (*Physalis mollis*), tomatillo (*Lycium berlandieri*), brasil (*Condalia obovata*), careless weed (*Amaranthus* sp.), and sunflower (*Helianthus* sp.). All of these plants do best in loose soil and abundant sunlight.

The importance of woody plants as bob-white food producers appears to be much less than is commonly supposed. Acorns, chiefly of live oak, comprised only 5.45 per cent of the contents of 565 stomachs, and mesquite seeds only 1.39 per cent. Fruits of gum elastic (*Bumelia* sp.), western hackberry or granjeno (*Celtis pallida*), and black brush (*Acacia amentacea*), abundant in many of the localities where the quail

were collected, appeared in crops only occasionally as traces.

Woody plants or their equivalent in cover value, however, are essential to good bob-white range. Clumps of trees and brush serve frequently as refuge cover, especially when tall grass is scarce. Their principal utility, however, is for resting or "loafing" retreats during mid-day. Woody cover, which bob-whites apparently prefer for resting, has the following qualities: (1) it provides concealment; (2) the birds can walk about freely underneath; and (3) visibility from the cover is good. The structure and growth habits of southwestern Texas plants are such that relatively few furnish excellent resting or "headquarters" cover. Mesquite, for example, is ordinarily too open underneath except when in combination with tall weeds, shrubs, or cacti. Huisache is often fair cover when young, but poor when mature. Black brush and tasajillo (*Opuntia leptocaulis*) are frequently excellent, and prickly pear (*Opuntia lindheimeri*) is generally good. Western sumac (*Rhus minutifolia*) ordinarily provides good cover, while granjeno varies widely from poor to good depending on the structure of the individual plant. Live oak, in its brush form, is usually too light or too heavy, and at best it is only fairly good. Clumps of wild rose at least 3 years old ordinarily are excellent except when very dense at the base. Plum thickets often are satisfactory when lightly browsed, but their tolerance to browsing is low. Wild grape frequently is good cover when it grows over a fallen tree, a low limb, or a bush. Broomweeds (*Amphiachyris* and *Gutierrezia*) are inferior headquarters cover except when in very dense stands. Blackberry is excellent where grazed moderately, but the distribution of blackberry is limited in southwestern Texas and its value as cover, therefore, is local.

A clump of woody cover or its equivalent about 3 to 10 yards in diameter appears ample for a covey of bob-whites; the distribution of woody cover in an area apparently approaches perfection when clumps are available from 100 to 200 yards apart.

SOME PLANTS VALUABLE TO THE CHESTNUT-BELLIED SCALED QUAIL

Unlike the bob-white, the chestnut-bellied scaled quail often thrives in regions where the soil is relatively tight and heavy, thorny or brushy cover is dense, and weeds and grass are scarce. The bird makes up for a low proportion of weed and grass products in its diet, apparently by consuming many seeds of woody plants, and much green food. The seeds of various kinds of brush formed approximately 68 per cent of the contents of 32 crops collected in the winter of 1934-1935; and green food, chiefly wild carrots and clover, was 7.17 per cent of the total. Elbow bush (*Adelia angustifolia*) was the single most important source of food (30.9 per cent), but catclaw (*Acacia roemeriana*) was almost as productive (29.73 per cent). Capul (*Schaefferia cuneifolia*) and granjeno each appear to furnish about 3 per cent of the blue quail's winter food; the seeds of mesquite, desert yaupon (*Schaefferia pubescens*), black brush, and lote (*Condalia obtusifolia*) occurred in the crops in only small quantities. Seeds of cacti (tasajillo and prickly pear) seem to comprise only about 1 per cent of the food supply in winter.

Weed seeds of importance and their proportions in the total diet are: bluebonnet (*Lupinus subcarnosus*) 8.74 per cent; wild bean (*Phaseolus sp.*) 5.01 per cent; doveweed (*Croton punctata*) 4.02 per cent; and sensitive briar (*Neptunia pubescens*) 3.03 per cent. The grains of cultivated sorghums were eaten in larger quantities than seeds of any other grasses, but made up less than 1 per cent of the total food. Other grass seeds and weed seeds that are eaten, but apparently not in large quantities, except locally, include: milk vetch (*Astragalus nuttallianus* and *A. brauntoni*), parosela (*Delia* sp.), ground spurge (*Chamaesyce glyptosperma*), smut grass (*Sporobolus* sp.), bindweed (*Convolvolus incanus* ?), panic grass (*Panicum* sp.), matrimony vine (*Lycium berlandieri*), puccoon (*Lithospermum* sp.), and *Rivina humilis*.

TABLE 2

FIFTEEN IMPORTANT SOURCES OF WINTER FOODS OF THE CHESTNUT-BELLIED SCALED QUAIL

Name of plant		Number of crops containing	Percentage of total contents
Common name	Scientific name		
Elbow bush	Adelia angustifolia	10	30.90
Catclaw	Acacia roemeriana	14	29.73
Bluebonnet	Lupinus subcarnosus	2	8.74
Green food (leaves, chiefly wild carrot and clover)	Chaerophyllum sp. and Trifolium sp.	6	7.17
Wild bean	Phaseolus sp.	2	5.01
Doveweed	Croton punctata	6	4.02
Sensitive briar	Neptunia pubescens	5	3.03
Capul	Shaefferia cuneifolia	3	2.91
Granjeno	Celtis pallida	3	2.85
Tasajillo	Opuntia leptocaulis	4	.75
Milk vetch	Astragalus nuttallianus	2	.46
Parosela	Delia sp.	3	.40
Sorghum (chiefly redtop cane and hegari)	Sorghum sp.	4	.40
Mesquite	Prosopis glandulosa	3	.30
Ground spurge	Chamaesyce glyptosperma	2	.29

The food habits of the chestnut-bellied scaled quail are such that the birds can thrive in many areas where bob-whites could hardly exist, but the cover requirements of the species are evidently exacting. Blue quail will use a mixture of cacti and heavy brush in southwestern Texas, but they have been found in large numbers only where prickly pear and tasajillo cover was very dense. Heavy cactus cover may, in fact, be essential for the welfare of the scaled quail in southwestern Texas. It has been observed, for example, that the birds decrease when pack rats become abundant enough to destroy much of the prickly pear. Also, they decrease alarmingly or disappear entirely when the spines are burned from prickly pears and the cattle browse the plants closely. Where the chestnut-bellied scaled quail is desired, therefore, plots of cacti approximately 1 acre in extent should be left at intervals of about 100 yards.

SUMMARY

Preferred habitats of the bob-white in southwestern Texas are fairly open

sandy grasslands and farms that are not cleanly cultivated. Chestnut-bellied scaled quail have been found most abundant on densely grown tasajillo-prickly pear flats.

The most important winter foods of southwestern bob-whites are provided by panic grass (*Panicum texanum*), sorghums (*Sorghum* sp.), and doveweeds (*Croton capitatus C. punctatus*, and *C. texensis*). The most prominent plant foods in 32 crops of the chestnut-bellied scaled quail were seeds of elbow bush (*Adelia angustifolia*), catclaw (*Acacia roemeriana*), and bluebonnet (*Lupinus subcarnosus*).

Bob-whites require woody cover, principally for resting or "loafing" during mid-day. Clumps of woody cover 3 to 10 yards in diameter that provide concealment, freedom of movement underneath, and good visibility, are ideal. Black brush, tasajillo, and wild rose often meet these requirements. The distribution of woody cover appears to approach perfection when clumps are located from 100 to 200 yards apart. Cactus cover may be essential for the welfare of the chestnut-bellied scaled quail. When prickly pear is burned for cattle feed, therefore, clumps approximately 1 acre in size and about 100 yards apart may well be spared for quail cover.

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THE UTILIZATION OF RUSSIAN THISTLE BY WILDLIFE

W. S. Long

It sometimes happens that the most despised and noxious weeds, when studied carefully, prove to be of real value to man. This is true of the exotic Russian thistle (*Salsola pestifer*), which was accidentally introduced into the United States from Asia more than fifty years ago. Since that time, it has spread throughout the semi-arid portion of the west and extends as far east as central Kansas. It is found everywhere in this vast territory except in the high mountains. This weed grows to a height of from a few inches to four feet or more, depending upon conditions of soil and moisture. It occurs along roadsides and on overgrazed land, and at times, especially on abandoned or fallow dry-farms, grows in pure, dense stands. It is one of the first plants to appear after the sod is broken or disturbed. In the autumn its dry, ball-shaped tops break off at the ground and drift before the wind until they lodge against a fence or other obstruction. Under these conditions, it is known as a tumbleweed.

According to the Forest Service (1, p. W-165), Russian thistle rates as fair forage for all classes of livestock in the early spring before the spines harden. At this time, the young plants are soft and succulent and are eaten readily by grazing aimals. After the spines harden and the plants become tough, domestic stock will not eat them, except under certain conditions. In Utah, sheep often live throughout the winter, and grow fat, on dead thistles softened by rain or snow.

Although not as valuable as the perennial grasses, Russian thistle is a nutritious feed. It contains more protein and carbohydrates than clover, and as much mineral salts as alfalfa, although it is not as palatable as that plant. When ground, it has been found to be 93.9 per cent as valuable as cane fodder for fattening lambs.

If cut while green, Russian thistle makes good hay, although it should be fed in mixtures with other feeds whenever possible. During the drought of 1934, the farmers in western Kansas stacked many thousands of tons of thistle hay for emergency feed. It is extremely resistant to drought and is usually available when hay crops fail. It makes fair ensilage and is readily eaten in that form.

Because it is drought resistant and will grow on very poor soils, Russian thistle has a certain value as a cover plant in the prevention of erosion. The fact that it breaks off and leaves the ground bare during the windy spring months detracts from this value, but without these thistles, some areas would have no cover at all at any time of the year.

In addition to these beneficial aspects of Russian thistle, it has definite wildlife values. Field observations during the last five years show that certain birds and mammals make use of Russian thistle in the following ways:

As Food. During the winter of 1939-40, in northern Emery County, Utah, large flocks of horned larks (*Otocoris al-*

pestris) were seen feeding on the seeds of this plant. The snow around each clump of thistles was packed down by the feet of the birds, and examination of the plants showed that most of the seeds had been removed.

On January 14, and again on February 3, 1936, in Zion National Park, Utah, flocks of black rosy finches (*Leucosticte atrata*) were seen feeding upon Russian thistle; a specimen collected had its crop full of the seeds. The birds ran from plant to plant, taking a few seeds from each before hurrying on to the next one.

On September 8 and September 25, 1935, in Zion National Park, I saw Inyo chipmunks (*Eutamias quadrivittatus inyoensis*) gathering seeds of Russian thistle. They pulled the plants down with their front feet and filled their cheeks with the seeds. Perhaps other chipmunks and ground squirrels also eat them.

In Emery County, Utah, in January 1940, I found empty hulls of seeds that had been eaten by white-footed mice (*Peromyscus maniculatus*).

Two burrows of kangaroo rats (*Dipodomys ordii*) excavated on the Porphyry Bench in Carbon County, Utah, in the spring of 1939, contained quantities of young plants, still fresh and succulent, that had been stored in small side chambers.

Kelso (2) has shown that Russian thistle is an important item in the food of three species of prairie dogs.

As Escape Cover. In November 1934, on the Cimarron River, twelve miles north of Liberal, Kansas, several acres of Russian thistles formed a dense stand along the roadside. They were four feet high, and were almost impenetrable to a man on foot. A covey of bob-whites (*Colinus virginianus taylori*) lived in this dense cover and fed in an abandoned field of kafir corn across the road. Ring-necked pheasants (*Phasianus colchicus*) and song sparrows (*Melospiza melodia fallax*) also used these thistles as escape cover.

As Shelter Cover. A barn owl (*Tyto alba pratincola*) that was roosting on the ground in a large patch of Russian thistles, was collected in Seward County, Kansas, on November 6, 1934.

At Kanab, Utah, in March 1936, I found large numbers of wood rats (*Neotoma lepida*) living in a gully that was full of dry thistles. They had cut trails and runways through the weeds in every direction. Under this spiny cover they were safe from all enemies except weasels and snakes.

Experience while collecting mammals in southwestern Utah, in 1936, showed that windrows or dense growths of Russian thistles were the best collecting places for most of the common rodents. In addition to the wood rats mentioned above, harvest mice (*Reithrodontomys m. megalotis*), house mice (*Mus musculus*), white-footed mice (*Peromyscus maniculatus sonoriensis*), kangaroo rats (*Dipodomys ordii cupidineus*), and grasshopper mice (*Onychomys leucogaster melanophrys*) also were taken in such places.

As Nesting Cover. One instance of this use of Russian thistle has come to my attention. A farmer in El Paso County, Colorado, while burning a windrow of thistles on his farm early in June 1938, exposed a nest and eight eggs of the scaled quail (*Callipepla squamata*).

I have seen juncos (*Junco oreganus*)

feeding in dense growths of thistle, but was unable to determine what they were eating. Perhaps many species of finches and sparrows feed upon its seeds. Jack rabbits frequently are seen in places where thistles grow abundantly, but I have no evidence of any specific use by rabbits. There is no doubt that further observations will reveal many more forms of wildlife which utilize Russian thistle in one way or another.

I am indebted to A. E. Borell and L. V. Compton for critical review of the manuscript of this paper.

REFERENCES

1. FOREST SERVICE.
1937. Range Plant Handbook. U. S. Dept. of Agri., xxvi+125+17+213+157 pp.

2. KELSO, LEON H.
1939. Food Habits of Prairie Dogs. U. S. Dept. Agri. Cir. 529: 1-15.

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THE NEED FOR RESEARCH IN FUR ANIMAL PRODUCTION

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No other natural wildlife resource has been so productive over a long period and none has produced so much wealth as fur animals. Today having helped build our financial and industrial empire, furs still play an important part in the life of our country, in the life of every American. The value of the annual take of raw furs in the United States is about $50,000,000, and the annual turnover in the retail fur trade is approximately $300,000,000, including money paid for furs, dressing and dyeing, manufacturing, and other operations. The old fur traders and trappers made America the principal source of furs for the Old World. Today, such is the demand in our country and so diminished is our supply, that the United States imports many more furs than it produces. The total value of our fur imports is three times that of the exports.

Fur animals are the most valuable of our terrestrial wildlife resources from an industrial standpoint and it is a mistake not to include them in any general plan for conservation or in any program of wildlife research. A crying need in developing our local and National policies for the conservation of wildlife resources is more serious consideration of fur animals. They should be given as prominent a position in State and Federal administration as are game and fish.

Conservationists, trappers, landowners, fur tradesmen, fur farmers, and others look to the scientist for leadership in the development of basic information in the production and management of fur animals and they have appealed many times to the Federal and State governments for assistance. Little has been done, however, to develop our fur resources and there has been no systematic effort on the part of the State colleges and universities to extend their field of research to include fur animals.

In order to place fur-animal production and conservation on a comparable foundation with other wildlife resources, fundamental knowledge is essential, and this can be obtained only by a comprehensive program of research. Such a program might include the following.

Research work on reproductive cycles. Most of the study thus far on the reproduction of mammals has been concerned with domestic species, and the available definite information on fur animals is very meager, particularly as regards species of economic importance. A more exact knowledge of the reproductive cycles of North American fur animals could be applied in several ways. It would be of great value in determining the proper trapping seasons to safeguard the restoring and conserving of fur animals; in attempting intelligently to supplement the natural supply by restocking and transplanting; in insuring success in producing fur species in captivity; and in making possible a more efficient and economical control of predatory and other injurious species. The object of research on reproductive cycles would be to establish definitely the breeding period of valu-

able fur animals; the number of litters and young produced yearly; the type of embryonic development (whether uninterrupted or with a delay in implantation); the hormone control of the breeding cycle; the feasibility of artificial insemination in those species that might be raised in captivity; and the possibilities for producing or maintaining reproductive fertility by hormone or other treatment.

Breeding experiments should be undertaken with various fur animals under controlled conditions. Many of the problems to be solved require that the animals be confined. Studies can be undertaken of the inheritance of prolificacy; the fur quality, which includes color, sheen, and density; physiology of hair growth, including shedding; and of the factors involved in producing prime fur and leather. Measurements must be devised to evaluate with greater certainty all of these characteristics, especially fur quality.

Nutrition should be given serious study. No comprehensive research program would be complete without including feeding. It is true that digestion and metabolism, the chemical composition of foods, and the part played by various foods in growth, fattening, maintenance, reproduction, and economical production of pelts of high quality are more important in the production of fur animals in captivity, but experimentation would be more effective if guided by the results of research upon fur animals in the wild.

Populations, annual takes of fur animals, production per acre, sustained yield, carrying capacity, and many other subjects should be studied. These however cannot be correlated and properly investigated if fundamental research problems are not solved first.

It is highly evident that there are many interesting fur-animal problems that should be studied, and also that when some of them are solved, State Game and Conservation Commissions and other agencies will be enabled to proceed more surely, safely, and effectively.

Without the basis of an intensively planned program of research, all action is of a hit-or-miss nature. Experiments with fur animals are costly, in time and equipment, and the animals themselves are expensive and hard to obtain.

In addition, investigators with scientific training and the ability to conduct research are required, and the economic results of any given project are by no means certain. Private individuals therefore are not likely to do much experimenting, because they must confine themselves to operations that are fairly certain to produce immediate profits. Associations, organizations, or wealthy individuals might undertake some forms of research, but men change their minds and associations alter their policies, hence there is no assurance of continuity.

There are many reasons why fur-animal research must be conducted primarily by public institutions, but this can be done only in response to a sufficient public demand and with the active support of those who have a stake in the industry.

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TISSUE CHANGES IN WHITE-TAILED DEER (ODOCOILEUS VIRGINIANUS BOREALIS) ACCOMPANYING NATURAL INFECTIONS OF LUNGWORMS (GENERA PROTOSTRONGYLUS AND DICTYOCAULUS)[1]

Frans Cleon Goble

Lungworms have for some years been recognized as a factor in winter losses of game ruminants but their exact role has not been well understood. Numerous workers have demonstrated that the pathogenicity of parasites is conditioned by factors such as nutrition, exposure, and the presence of other organisms as well as by the relative number of the parasites harbored by the host. It is toward a more complete understanding of the interrelations of these factors, of what these worms do within their hosts and how the infected animals react to them, that this investigation was directed.

Early in 1934 studies on the lungworm problem in Michigan deer were initiated by Dr. E. C. O'Roke of the University of Michigan School of Forestry and Conservation. At the outset these investigations were carried on with emphasis on the life history of the parasite and the game management aspects of the problem. As the work progressed the need for a more detailed study of the effects of the parasites on the host was felt and unusual opportunity for the collection of material suitable for histopathological study was afforded by periodic shootings of deer on the Edwin S. George Reserve, necessitated by overpopulation of that area.

This Reserve, owned by the University of Michigan and administered by the Museum of Zoology, comprises two square miles of grassy uplands, oak-hickory forest, tamarack swamp, and cassandra bog in Livingston County, Michigan, with a deer population varying between one hundred and one hundred and fifty, living under natural wild conditions.

During the years 1934 through 1937 about two hundred autopsies were performed, detailed observations being confined in most cases to the respiratory tract. However, more or less complete material was collected from twenty animals in this series, fixed and subjected to histopathological examination, the results of which are set forth in this dissertation. A preliminary report on the other phases of the study was published by Dr. O'Roke (1936).[2]

Historical Note

Scattered observations on the pathological effects of lungworms on domestic ruminants were made during the nineteenth century, but due to crude micro-

[1] A dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Science, in the University of Michigan, 1939.

[2] The guidance of Dr. E. C. O'Roke and the interest of Dr. G. R. La Rue during the course of this investigation are deeply appreciated. I am greatly indebted to Theodore Kramer for his valuable cooperation in the preparation of the microphotographic material. I also wish to acknowledge the courtesies of Dr. E. C. O'Roke, Dr. Adolph Murie, and Lawrence Camburn in the collection of animals and tissues for this study.

technical methods and parasitological concepts, the lesions were often imperfectly described and confusedly interpreted. During the last part of the century an abundance of literature appeared but I feel that little purpose would be served by a review of the errors of parasitologists with secondary interest in the hosts and the omissions of veterinarians seeking generalizations on lungworm disease.

The inadequacies of the text-book and periodical descriptions of the tissue changes due to lungworm infestations have been noted and commented on by both Joest (1908) and Daubney (1922). It was their feeling and is mine as well, that a collective treatment of lungworm lesions results in a confused conception of the effects of the infestations and that it is desirable to construct separate pathological pictures, describing the action of each kind of worm in each host. Joest (1908) and Daubney (1922) made this step in their basic work on *Dictyocaulus viviparus* in cattle. M'Fadyean (1894) in his attempt to unravel the confusion concerning the species involved in the lungs of sheep, contributed to this field of specific pathological description the picture of the lesions arising from *Protostrongylus rufescens* invasion.

Nieberle (1924) has given a rather good critical review of the veterinary literature on the lungworms up to that date. This work is well illustrated with original cuts and reprints from the authors quoted in the compilation.

With these few words on the literature of the subject, I should like to postpone further remarks and references to previous papers to those points in this study where they logically fall.

ORGANISMS INVOLVED

The lungworms infesting deer in Michigan, according to O'Roke (1936) are:

Dictyocaulus viviparus (Bloch, 1782)
Dictyocaulus filaria (Rudolphi, 1809)
Protostrongylus coburni (Dikmans, 1935)
Pneumostrongylus sp. (probably *alpenae* Dikmans, 1935)

These identifications were made by Dikmans (1934, 1935) from specimens sent to him by O'Roke and Coburn.

All four of the above are of the family Metastrongylidae, most of the members of which are parasites in the trachea, bronchi, and lungs of mammals, although the adults of a few species are found in other organs such as pulmonary arteries (*Angiostrongylus vasorum*), dorsal lymph spaces (*Elaphostrongylus odocoilei*), and frontal sinuses (*Troglostrongylus troglostrongylus*).

Metastrongylidae comprise one family of the large superfamily Strongyloidea or bursate nematodes, distinguished by the possession by the males of a cuticular bursa copulatrix supported by rays. Other families of this group are the hookworms, gapeworms, gizzard worms, and two others of gastro-intestinal parasites. Practically all of these worms are blood-suckers, the lungworms being no exception.

The genus *Pneumostrongylus* has been infrequently found and this report will be confined to the genera *Dictyocaulus* and *Protostrongylus* which are differentiated by habit and behavior as follows:

Dictyocaulus usually occupies the low trachea, and large and medium bronchi in its sexually mature form. Its eggs are

completely embryonated at the time of deposition and hatch soon after laying. The life cycle as shown by Daubney (1920) is direct, the migration between the intestine and the lungs of the host, involving the lymphatics, according to the Hobmaiers (1929) some time being spent in the mesenteric lymph nodes.

Protostrongylus ordinarily is found in the smaller bronchioles and alveoli and apparently may also burrow about through the pulmonary parenchyma, often being very difficult to locate in the adult stage. The eggs are unsegmented when laid and may be found in all stages of segmentation in the lungs, deposition taking place into the alveoli. The Hobmaiers (1930) believe an intermediate host is involved in the life cycle of at least *P. rufescens*. They list (1929, 1930, 1934) gastropod hosts for *P. rufescens* and a related form *Muellerius capillaris* as well as for *Elaphostrongylus odocoilei*. Cycles involving intermediate hosts of very diverse types are known for other members of the family, for examples: *Aelurostrongylus abstrusus* of the cat with larvae in the mouse and *Metastrongylus elongatus* of the pig with larvae in earthworms.

Metazoan parasites normally inhabiting the lungs of domestic, game, and fur-bearing mammals range from flukes (*Paragonimus*) through cestodes (*Echinococcus*), roundworms (Metastrongylidae, *Eucoleus*, *Oslerus*), and tongue worms (*Linguatula*) to mites (*Pneumonyssus*).

Metastrongylidae of the genera *Crenosoma, Aelurostrongylus, Angiostrongylus, Troglostrongylus, Skrjabingylus* and *Filaroides* infest a variety of carnivores, including many fur-bearers, while the organisms which concern us in the study of the pathology of domestic and game ruminants fall largely in the genera: *Dictyocaulus, Protostrongylus, Muellerius, Pneumostronglylus, Elaphostrongylus.*

PROCEDURE

Autopsies were performed in the field as soon as possible after the shooting of the animals. Excess blood was removed from the tissues by washing in well water, after which slices from 15 to 30 millimeters thick were made, to be placed in Bouin's picro-formol for fixation. Before fixation each lung was split with scissors down the main bronchi and out the smaller bronchi, this procedure exposing *Dictyocaulus* when present. Larvae could be found in the mucus scraped from the surface of the bronchi of animals infected with *Protostrongylus.*

Samples were taken from at least five places in each lung. From some animals at least twenty blocks of tissue were removed from the lungs for microscopic examination. It is felt that this sampling furnishes a representative picture of the condition of the lung. In each case the entire remaining lung was carefully examined fresh, then sliced and preserved in formalin, to be dissected in detail after hardening.

Alcohol washing and dehydration followed fixation, clearing in xylene leading to paraffin infiltration and embedding. Sections of various thicknesses between 5 and 12 micra were routinely stained in Mayer's hemalum and counterstained with eosin. Supplementary sections were stained in Mayer's muci-hematin to demonstrate mucin and Weigert's methyl violet to show fibrin, if present. Sections thinner than 5 micra

TABLE 1

No.	Sex	Age	Date	Infection	Bronchi and Bronchioles					Lung			
					Exudate	Mucosa	Submucosa	Muscularis	Lymphoid tissue	Alveoli	Septa	Pleura	Nodules
1	M	F	3-12-34	P	1–2	2	1	1	0–1	1	3 H	1	
2	M	A	6-19-34	P	0	0	E & L	0–1	1–1	1 spa	3	1 A	F & M
3	M	A	7-10-34	P	0–1	0	0	0	0–1	1	3	1 A	
4	M	Y	7-27-34	P D	1	0	0	0	0–1	2 spa	3 H	2 A	M
5	M	A	7-30-34	P	0–1	0	0	0	0–1	1 spa	3	1	
6	M	S	3- 1-35	P	Edema	2	0	0	0	Edema	1 H	0	
7	M	A	7- 9-35		1	0	0	1	1	1 spa	1	0	
8	M	A	5-23-36		0	0	0	0	0	0	0	0	
9	M	S	10-31-36	P	0–1	2–1	Edema	0	0	3 spa	1 H	1	
10	F	Y	9-20-37	P	1–2	0–1	1 H	1	1–2	1 spa	2 H	1 A	F
11	M	Y	10-14-37	P D	1–2	1–2	L H	1	1–2	1 spa	2 H	1	
11a	M	Y	10-14-37	P D	3	2 L	1 L H	0–L	3	atalect.	2 H	1–2	
12	M	F	10-20-37	D	0–1	1 E	E L H	L 1	1–2	1	1 H	1	
13	F	S	10-21-37		1	1	1 H	1	0–2	1	2 H	1	F & M
14	F	A	10-22-37	P	1–2	1–0	1–0	1	0–1	2	2 H	1	
15	F	F	11- 5-37		1	1–2	1 L	1	1	1	1		M
16	M	A	12-20-37	P	0–1	0–1	0–1	0–1	0–1	2 spa	3 H	1	
17	M	A	12-21-37		0	0	H	1	0	1 spa	2 H	1	
18	M	A	12-21-37	P	0–1	0–1	1	1	0–1	2 spa	2 H		M
19	F	A	12-21-37		0	0	0	0	0–1	2	1 H	1	
20	M	F	12-21-37	D	1–3	1 L	1 L H	0 L	1	1	2 H	1	

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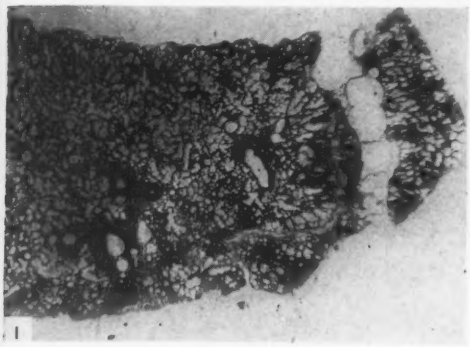
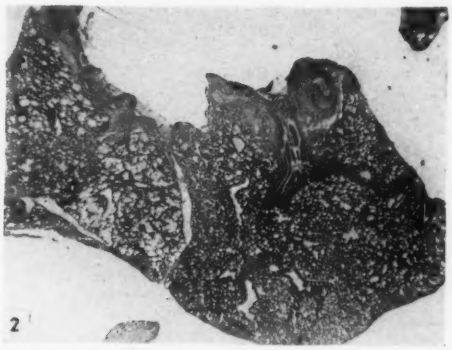
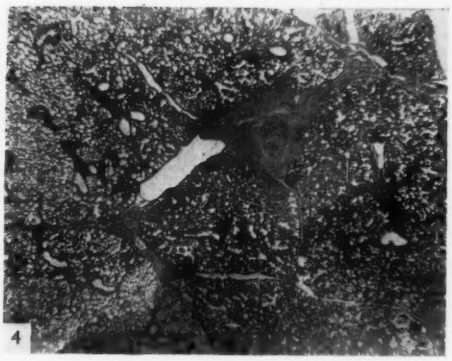
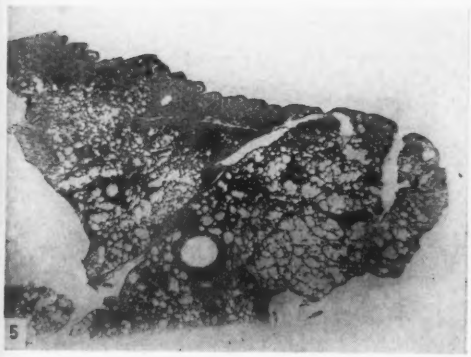








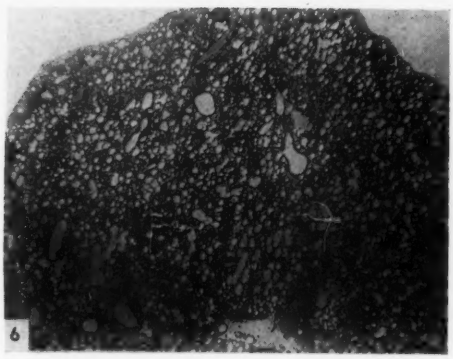
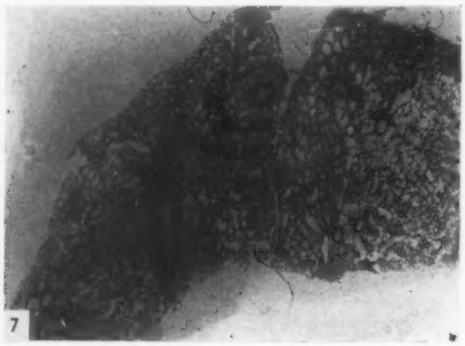


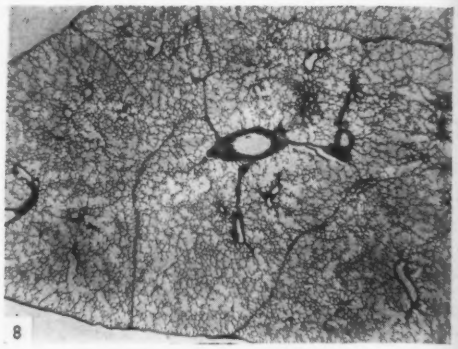
Fig. 1. #1 showing septal hyperplasia and interlobular emphysema.
Fig. 2. #2 showing septal hyperplasia.
Fig. 3. #3 showing septal hyperplasia.
Fig. 4. #4 showing septal hyperplasia, a fibrosed nodule with collateral hyperemia.
Fig. 5. #5 showing septal hyperplasia and sub-pleural atalectasis.
Fig. 6. #6 which died with a severe hemorrhagic pneumonia, associated with the presence of thousands of lungworm eggs and larvae.

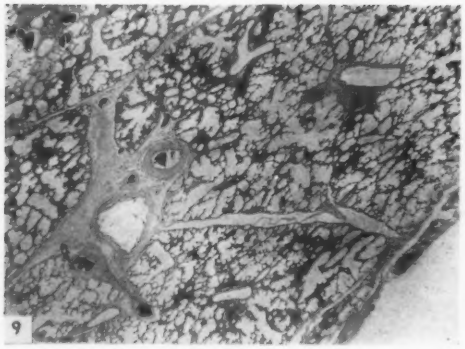
Magnification in each case is 6×.

EXPLANATION OF PLATES

(All figures except No. 36 are of sections of the lungs of white-tailed deer.)







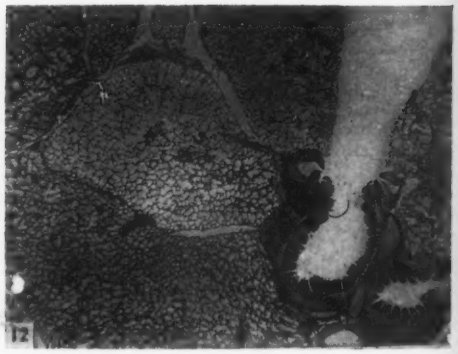


Fig. 7. #7 showing mild septal hyperplasia.

Fig. 8. #8, a practically normal deer lung, showing slight atalectatic tendencies and minimum of bronchial lymphoid tissue.

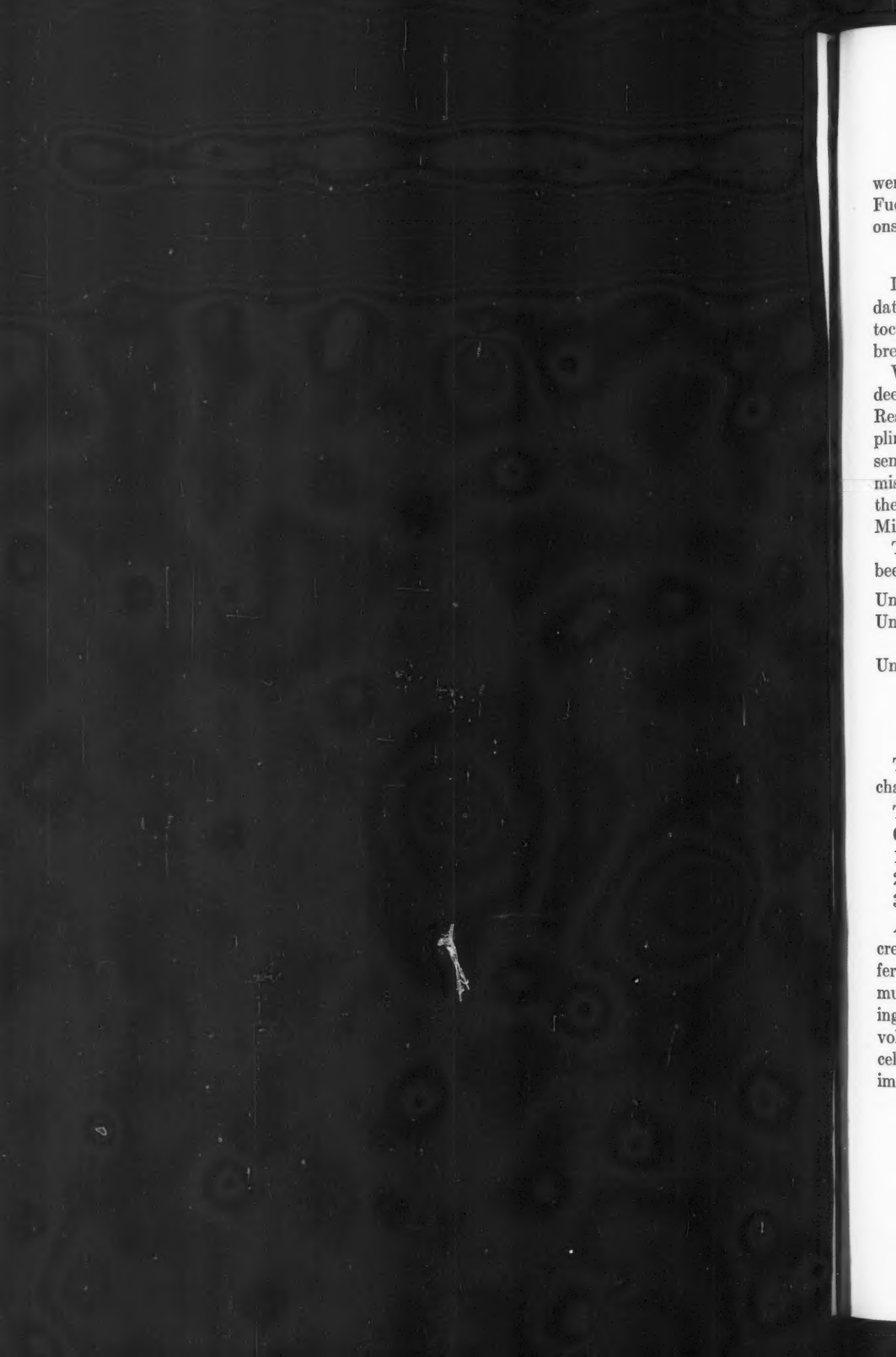
Fig. 9. #9 showing emphysema, sub-pleural atalectasis, and edema.

Fig. 10. #10 showing a region in which the presence of *Protostrongylus* has provoked proliferation of the bronchioles and infiltration with eosinophilic polymorphoneuclears.

Fig. 11. #11 showing, on the left, septal hyperplasia and atalectasis due to the presence of numerous eggs and first stage larvae of *Protostrongylus*.

Fig. 12. #12 showing little change from the normal although the split bronchus at the right contained seven adult specimens of *Dictyocaulus*.

Magnification in each case is 6×.



were stained by Gram and Carbol-Fuchsin methods in an attempt to demonstrate bacteria.

SUMMARY OF AUTOPSIES

In the preceding table (Table 1) the data from the individual autopsy protocols on each animal have been abbreviated and tabulated.

With the following exceptions these deer were all from the Edwin S. George Reserve and were shot in a random sampling of the area. #6 and #9 were both senile animals which died on the premises of E. C. Smith, who had kept them for over seven years at Dixboro, Michigan.

The following abbreviations have been used in the table:

Under Sex: M male, F female
Under Age: F fawn, Y yearling
A adult, S senile
Under Infection: P *Protostrongylus*
D Dictyocaulus

The numbers used indicate degrees of change in the tissues involved.

Thus:
0 Normal
1 slight change
2 moderate change
3 considerable change

Although all these changes are increases they differ in nature in the different tissues. Thus, the increase in mucosa and sub-mucosa involves swelling, while that in lymphoid tissue involves an increase in the number of cellular elements and that in the alveoli implies emphysema.

E = eosinophiles
L = lymphocytes
H = hyperemia
A = adhesions
spa = sub-pleural atalectasis
F = fresh nodules
M = mature nodules

THE LOCAL DEFENSE REACTION

Taliaferro (1929) has outlined the cellular defense reactions with reference to parasites, basing his discussion on Maximov's (1927) "Morphology of the Mesenchymal Reactions." The three phases of the local defense reaction or inflammation should be borne in mind as the pathological conditions described in the present investigations are examined.

The local defense reaction proceeds through a series of three steps, each of which involves one of the three categories of cells which Maximov recognizes in the connective tissues and blood. The process is always fundamentally the same, varying according to whether it is septic or sterile and with certain other conditions. The three steps are:

1. Mobilization of hemocytes (polymorphonuclears, microphages)
   a. If aseptic they are scanty and soon disappear.
   b. If septic they appear in large numbers.
      1) They phagocytize and secrete bactericidal and detoxifying substances.
      2) They do not multiply or transform into other cells.
      3) They may be removed later by blood and lymph but most degenerate and disappear in situ.
   c. Eosinophiles are frequently mobilized in parasitic infections.
      1) They defend against foreign protein, and function in allergic reactions.
2. Mobilization of macrophages or mononuclear exudate cells.
   a. The origin of these is uncertain. Maximov claims they have a mixed origin

from histiocytes and agranulocytes. He believes a complete transition series can be found between lymphocytes and blood monocytes and histiocytes.

b. Macrophages have much greater potentialities for defense and repair, phagocytosis of foreign bodies, living and dead, liberation of enzymatic substances, and elimination of foreign materials.

c. They remain after the inflammation subsides, taking on the structure of the normal histiocytes of the region or later become fibroblasts.

3. Regenerative phase, depending on fibroblasts.

a. These arise from preëxisting cells of the same type and to a much less extent from endothelium of the small blood vessels.

b. They repair the wound and provide fibrous capsules to isolate foreign bodies or tenacious abscesses not cleared up by the macrophages.

Bloom (1937) has recently shown transformation of lymphocytes to granulocytes (eosinophiles) in vitro to take place in the presence of the proteins of certain nematodes (*Ascaris* and *Trichinella*).

FINDINGS IN THE INTESTINE

M. Hobmaier (1934) reported that in massive artificial infections of *Metastrongylus* in pigs, lesions attributable to the migrating nematodes could be found in the wall of the intestine. These consisted of inconspicuous infiltrations of eosinophiles in the stroma of the villi, in the sub-mucosa, rarely in the muscularis around vessels and even in the subserosa. These infiltrations were more numerous in the region of the colon and caecum, both as scattered cells and aggregations. Local eosinophilic infiltration was strongly marked on the mesentery in the vicinity of the lymphatic vessels between the intestine and the mesenteric lymph nodes.

Mönnig (1938) says that young larvae of *D. filaria*, passing through the intestine of the sheep may irritate the mucosa to the point of causing diarrhea. He also lists diarrhea as one of the symptoms of this phase of *D. viviparus* in calves.

Sections of intestine at three levels, small intestine, caecum, and colon, were examined in this investigation. These organs were obtained from twelve deer, eight of which had lung infections, as evidenced by the presence of *Protostrongylus* eggs in the lungs.

No changes attributable to migration of larvae were found.

FINDINGS IN THE LYMPH NODES

Under Hobmaier's (1934) experimental conditions with *Metastrongylus* in pigs, practically all the lymph nodes of the intestine were invaded, most heavily however in the region of the caecum and colon, less toward the rectum and stomach. He found no larvae in any node not directly connected with the digestive tract.

With *D. filaria*, the Hobmaiers (1929) and Shaw (1934) have found the comparable stages in the lymphatics and lymph nodes of sheep.

In this study the bronchial lymph nodes were examined in 15 cases and the retroperitoneal and mesenteric lymph nodes in 12 cases. No evidence of past or present migrations of larvae were found in any of the bronchial or retroperitoneal nodes, and the mesenteric nodes were negative with the exception of one.

This exception was case #13, a senile doe which had no lungworm eggs or adults in the lungs but which did show several fresh foci of invasion of the lungs by fourth stage larvae, and nu-

merous nodules in which these invaders had been walled off by eosinophiles, lymphocytes, and fibroblasts. The changes in the mesenteric node of this animal consisted of fibroblastic proliferation in the region of the hylus, around a calcifying body, part of which resembled the cuticular substance of a larval nematode. Foreign body giant-cells closely applied themselves to the periphery of this entrapped worm.

It is believed that the reaction of the host which ensnares these third and fourth stage larvae and destroys them before they reach sexual maturity is a mechanism of resistance to parasitic invasion in so-called immune animals. This doe which, from the hyperplastic septa and increased bronchial musculature seemed to have been previously infected, was old but in good flesh and apparently resistant.

FINDINGS IN THE LIVER

In view of M. Hobmaier's (1934) failure to find more than three foci, out of about one hundred samples of pig liver, which showed evidence of a recent migration of *Metastrongylus*, it would not be surprising to fail to locate such areas in the livers of deer with natural infections of much smaller numbers of worms than were involved in the heavy artificial infections of Hobmaier.

Livers of twelve deer were examined microscopically in fixed preparations with negative results so far as identification of lesions attributable to lungworm migration.

CHANGES IN THE LUNGS DUE TO PROTOSTRONGYLUS COBURNI

Attributable to the Fourth Stage Larvae. These larvae arrive from the blood stream, having probably entered it from the lymph channels. Reaching the arterioles and capillaries of the lungs, they are embolized and must break out of the blood vessels to reach the air spaces. This process is not uncommon among nematodes, especially strongyloids, many of which undergo a migratory phase in their life cycles, passing from the pulmonary capillary bed out into the alveoli, from which they make their way up the bronchi and trachea to the larynx and epiglottis to be swallowed and attain their definitive habitat in the alimentary tract (*Nippostrongylus, Ascaris, Necator*, etc.).

This process is always accompanied by some hemorrhagic change, depending more or less directly on the number of larvae passing through and thus varying between minute petechiae and large areas of bleeding. In the case of *Protostrongylus* larvae, which probably seldom enter the lungs in the huge numbers comparable to those involved in artificial infestations in domestic animals, the lesions are confined to miliary spheres up to five millimeters in diameter, of purplish hue when fresh.

Microscopically these show hemorrhagic foci, in the center of which larvae may or may not be found, surrounded by eosinophiles when present. Even in nodules in which larvae are not found, there are usually eosinophiles in abundance throughout the region, decreasing in numbers toward the periphery. The tissue adjacent to these regions of miliary pneumonia shows severe hyperemia. Polymorphonuclear neutrophils, when present, are exceedingly sparse.

These focal lesions, just described, appear to be the manifestation of the

reaction to fourth stage larvae on their exodus from the blood stream into the lung. The subsequent fate of the larvae depends on the degree of tissue and cellular response. In many cases the larvae escape from the site of the lesion and proceed to grow to maturity in the air spaces, bronchioles, and small bronchi. In other cases the reaction about the larvae may be so severe that they are trapped in a mass of eosinophiles and lymphocytes and retained at the original focus. This reaction is accompanied by severe collateral hyperemia, and by fibroblastic and angioblastic proliferation, leading to nodule formation.

In the more mature nodules, the larva, surrounded by a mass of eosinophiles and lymphocytes appears in the center of a layer of radially arranged epithelioid cells, probably of reticuloendothelial origin and related to the epithelioid cells of true tubercles. Outside this layer is a zone of fibro- and angio-blastic proliferation in which there are more lymphocytes than eosinophiles, though both are present. Figure 28, which is an enlargement of Figure 27 shows these zones clearly.

Subsequently the worm is broken up and disappears, giant-cells frequently being found during this process. Simultaneously the epithelioid layer loses its radial character to take on the aspect of Figure 26, in which calcification of the necrotic mass of leucocytes in the center is observable. The extent of the encroachment of these nodules on the surrounding tissue varies from the average shown in Figure 27, to the mass shown in Figure 25, which, as in Figure 15, involved considerable collateral alveolar and bronchial tissue. Figure 4 shows a completely fibrosed nodule in which no traces of the worm or the process remain.

Lesions were found in deer #10 that differ from the nodular type usually found where the tissues have reacted to the invasion of fourth stage larvae. Although the involved region is spherical and contains numerous eosinophiles, these lesions differ in that they involve bronchiolar tissue, which is undergoing considerable proliferation. This condition, shown by Figure 10 seems to be comparable to one described by M'Fadyean (1894) in sheep infected with *Protostrongylus rufescens.*

Although considerable proliferation of epithelial tissue has taken place, there seems to be no indication of a tendency to malignancy that would supplement the suggestions of Aynaud (1926) as to the verminous origin of certain cancerous growths in the lungs of sheep.

Attributable to the Adults. Adult Protostrongylinae are found in small bronchi, bronchioles, and in the pulmonary parenchyma. Adults have proved consistently difficult to find, the picture presented by microscopic sections seeming to indicate that they wander extensively throughout the lungs, the females depositing eggs more or less indiscriminately along their paths. In cases in which deposition has not been extremely heavy, eggs may be found in groups of one to four or five along an imaginary line which may have been the course of the parasite. Observations on fresh lung material, squeezed between glass slides, gives the same impression of linear distribution of single or grouped eggs.

Eggs of *Protostrongylus coburni* have not been found in "nests" or "Brutknoten," such as have been observed in lungs of other animals with other species of lungworms. The presence of these

nests is probably an indication that in these other species each female ordinarily is localized or ordinarily deposits most of her eggs at one focus, which is not the habit of *Protostronglyus coburni*.

The following paragraph from Mönnig (1938) presents roughly the consensus on the pathology produced by *Protostrongylus rufescens* in sheep, goats, rabbits, and hares. "The worms live in the small bronchioles, where they produce an irritation and local areas of inflammation develop. The resulting exudate fills the alveoli, which are situated distally to the seat of the parasites, and the inflammatory process spreads to the peribronchial tissues. The affected alveolar and bronchiolar epithelium is desquamated, blood vessels are occluded, and an infiltration with round cells and proliferation of connective tissue take place in the area. The result is a small focus of lobular pneumonia, roughy conical in shape and yellowish-grey in color. The pleura at the base of the focus may be involved in a fibrinous pleuritis. The number of such foci in the lungs depends on the number of parasites present. As a rule the animals show no definite symptoms, although severe infections would undoubtedly affect the general health, and the weakened lungs are susceptible to bacterial invasion which may produce acute pneumonia."

This description would seem to imply a pathologic process due to the activity of the adult worms in the lung tissue, but the work of M'Fadyean (1894) showed the presence of eggs in these consolidated foci and it is my opinion that the major pathology in these cases is due to the presence and activity of the eggs and larvae rather than the "spread" of the inflammatory process resulting from the presence of adults in the bronchioles. The difficulty encountered in finding adults of *Protostrongylus coburni* in lungs showing extensive changes due to large numbers of eggs and larvae, seems to support this view.

Attributable to the Eggs and Newly Hatched Larvae. Unsegmented eggs are deposited throughout the lung chiefly in the alveoli. Leucocytes, mainly agranulocytes, soon surround these eggs, filling and obliterating the alveoli which contain eggs. Eggs in all stages of segmentation up to embryonic worms are found within these aggregations of inflammatory cells. Figures 31 and 32 illustrate this condition. In Figure 31, there appears a clear space between the morula-like mass of the segmenting egg and the shell, which space is greater than that observed in unfixed eggs. Some shrinkage of the protoplasm of the egg has taken place in fixation, the shell portion remaining rigid. Figure 32 shows unhatched eggs, containing larvae.

The epithelial and endothelial portions of the lung are highly reactive and the proliferating epithelium of the alveoli is sometimes very difficult to differentiate from macrophages and monocytes. The eggs of *Protostrongylus* are not, of course, of phagocytizable proportions and the reaction, whether lymphocytic, macrophagic, monocytic, or epithelial is accompanied by fibroblastic proliferation from the wall of the alveoli, resulting in obliteration of the air spaces and a condition of chronic productive inflammation, since resolution is delayed by the insoluble nature of the egg.

The eggs proceed to segment, the embryo forms, and eventually hatching takes place. Following this the larvae generally escape from the agranulocytic

aggregations which surround them and and make their way to the bronchioles, bronchi, and trachea. As the affected alveoli are abandoned, resolution produces additional fibrous tissue. Some of the eggs apparently die during segmentation and some of the larvae are unable to extricate themselves from the cellular exudate. The reaction to the presence of these eggs and larvae frequently approximates that made toward foreign bodies, giant-cells being found applying themselves to the periphery of the eggs.

To a process involving the connective tissue framework of the lungs and walls of the alveoli, resulting in the formation of new connective tissue and obliteration of air spaces, the term interstitial pneumonia is applied. It may follow various conditions including bronchopneumonia, chronic bronchitis, atalectasis and hyperemia, or may be induced by the aspiration of inorganic substances. In *Protostrongylus* infections, some degree of all these conditions may exist in the lungs. Interstitial pneumonia has been a constant finding in the lungs of deer harboring *Protostrongylus*, is entirely absent in a deer known never to have been infected (#8), and is thought to be indicative of previous infection in deer that showed no infection at the time of collection, (#7, #13, #17).

It is important to emphasize here that the term pneumonia is frequently used loosely and without proper qualification as to type. The term interstitial pneumonia carries the implication of a process differing considerably from that of acute lobar pneumonia, lobular and bronchopneumonia, or tuberculous pneumonia. The differences involve both extent and character of the cellular and non-cellular exudates, as well as duration and sequelae of the process.

In the absence of malnutrition, exposure, and bacterial invasion recovery is apparently the rule. Thickened alveolar septa, regions of collapse, and compensatory emphysema do not visibly affect the health of the animals. And though large numbers of alveoli are obliterated the respiratory surface does not seem to be reduced to a degree incompatible with an active existence.

Staining the pneumonic areas by the usual methods for revealing microörganisms (Gram, Carbol-Fuchsin) failed to reveal the presence of any number of bacteria. Facilities for culturing from these tissues were not available and there remains the possibility that some small numbers of organisms not detectible in stains of thin sections are present.

It is my belief, however, that the process I have observed is practically aseptic. The hemocytic elements of the exudate are nearly 100% agranulocytic in the areas where no fourth stage larvae or adults are present. Were bacteria present in these lungs, to the extent of demanding consideration as etiologic agents in the pathologic changes, a marked polymorphonuclear reaction would be expected. I do not believe that the few microphages encountered, thinly scattered through these lungs, indicate a purulent process due to bacterial invasion.

The presence of first stage larvae in the bronchioles and bronchi may provoke considerable aggregation of lymphoid cells in the walls of these air passages. Lymphocytes may also pass into the lumen and mingle with catarrhal exudate which frequently appears. The

presence of this mucous exudate is noted here in anticipation of the following discussion of lungworms in relation to bacterial pneumonias.

Recent observations of Marsh (1938) and Potts (1938) on pneumonic disease in the Rocky Mountain bighorn have revealed the simultaneous presence of lungworms (*Protostrongylus stilesi*), a diphtheroid (*Corynebacterium pyogenes*), and the bacterium of hemorrhagic septicemia (*Pasteurella oviseptica*) in the lungs of mountain sheep dead of pneumonia. Marsh, however, separates the disorders into two types, one of which he calls verminous pneumonia, a chronic condition in which the deaths are principally of mature sheep, the other an acute pasteurellosis of lambs. He remarks, "Our interpretation of the findings in the principal group of cases of pneumonia in bighorn sheep is that the primary etiological factor in this disease is the infestation with the lungworm, *P. stilesi*, with secondary bacterial invasion. The organism principally involved is the dipththeroid *Corynebacterium pyogenes*, although a *Pasteurella* is constantly present in the diseased lungs."

The following paragraph from Potts' (1938) paper on the same problem with more emphasis on the pasteurellosis leads us to another aspect of the subject. "Originally it was assumed the disease (hemorrhagic septicemia) was highly contagious, but more recent information greatly discounts the possibility of contagion, and indicates that high herd mortality is due to simultaneous exposure to bad weather, malnutrition, etc. The causative organism is apparently normally present, but dormant, in most individuals, and when conditions are favorable for its activity it attacks those animals whose resistance is low."

These papers seem to suggest an outline of relationships in a lungworm-exposure-bacteria complex. Nungester and Jourdonais (1936) pointed out the importance of the mucinous secretions of the host in the etiology of lobar pneumonia. Pneumococcus pneumonia has proved difficult to produce artificially in experimental animals by the respiratory inoculation of pneumococci alone, but the introduction of the organisms simultaneously with mucin or materials of similar viscosity produces the infection. They state, "A complete understanding of the etiology of lobar pneumonia must enable us to explain why normal individuals may harbor virulent pneumococci in the upper respiratory tract and yet not contract the disease. Also a full knowledge of the etiology of lobar pneumonia must explain the mechanism by which the predisposing factors in the etiology of this clinical condition, as exposure to cold, dust and fatigue, lowers the resistance of the host. . . . In this hypothesis we refer especially to the aspiration of excessive amounts of mucinous secretions into the bronchioles and alveoli where such secretions may exert a protective action on the bacteria against phagocytic defenses of the host."

The fact that the presence of lungworms in either larval or adult form incites excessive mucus production has been demonstrated. Coryloss and Birnbaum (1929) attribute lowered resistance of lung tissue to atalectasis, following the plugging of bronchi with mucin. This situation also exists as a result of lungworm infestation. Under these con-

ditions the normally harmless bacterial inhabitants of the lower respiratory tract could increase to the point of establishing a well defined lobar pneumonia.

It should be understood that the introduction of the concepts of pneumonia of the last few paragraphs into this discussion of the possible mechanism of winter losses in deer is largely speculative inasmuch as almost nothing is known of the bacteriology of either the normal or pathological respiratory tract of deer. Investigation in this field is needed and should supply information which will allow an evaluation of the role of bacteria in the process. In the areas in which the present study has been carried on, in fact in Michigan as a whole, there has been no indication that deer have suffered from pasteurellosis or from infections with *Corynebacterium*.

Whitlock (personal communication, 1939) says that he has observed that lungs of winter-killed deer, which often contain numerous *Protostrongylus* larvae, manifest a condition grossly similar to the red hepatization stage of lobar pneumonia. This is in contrast to my findings in healthy deer even when large numbers of larvae were present in the lungs and suggest that factors other than worms are involved in these pneumonias. Isolation of bacteria from these lungs has apparently not been attempted.

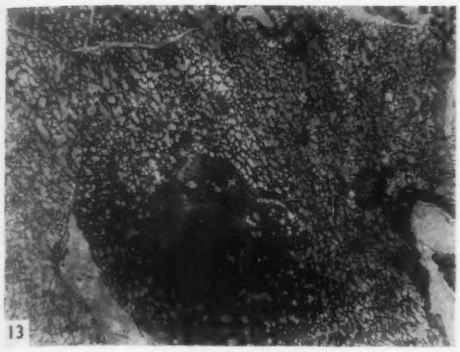
O'Roke (unpublished research) has considerable data showing a much greater incidence of *Protostrongylus* in deer found dead than in deer shot in apparent health. This points to an association of lungworms with winter losses if not to a cause and effect relationship between them.

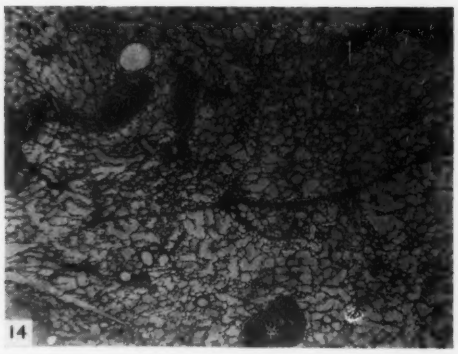
In addition to the general processes, already discussed, a group of phenomena of more localized nature are observed associated with the presence of eggs and first stage larvae.

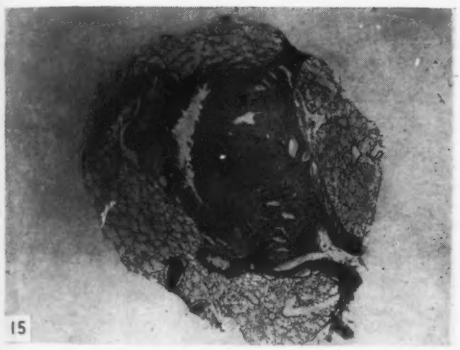
In regions where egg deposition and hatching is taking place, there is a tendency for agranulocytic hemocytes to form aggregations in the bronchiolar walls. Sometimes larvae of the first stage are found in the lumina of these bronchioles; often they are not. Such a bronchiole may be seen in Figure 30. This condition is not unusual but in one case, deer #18, the hyperplasia of lymphocytic tissue in the region of bronchioles in which larvae could be demonstrated, had progressed to the extent of involving whole lobules, the rapidly proliferating lymphoid aggregations causing pressure atalectasis of the collateral alveoli, as is shown by Figure 35.

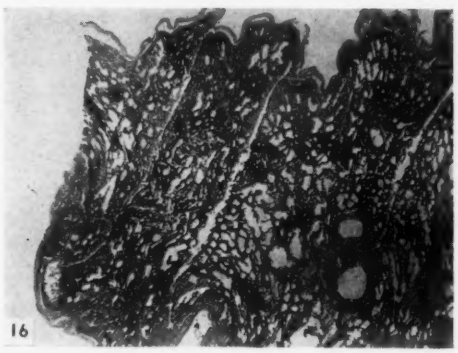
Another finding, which varies considerably in degree, is the hypertrophy of the bronchiolar musculature. Figure 14 shows this condition which has been observed by other authors in sheep with *Protostrongylus* and *Muellerius* infestations. There seems to be no direct quantitative correlation between this muscle change and the degree of infestation as manifested by the numbers of eggs and larval worms, nor does the hypertrophy appear to be necessarily associated with any of the other tissue changes.

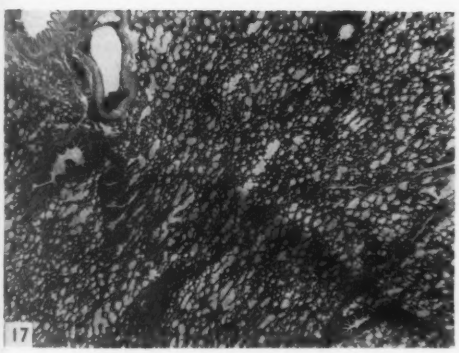
A condition of considerable pathological interest but of undefined clinical importance, was observed in deer #11, apparently as a result of the concurrent expression of severe catarrhal and agranulocytic reaction to the presence of large numbers of eggs and newly hatched larvae. Figure 24 shows a portion of the











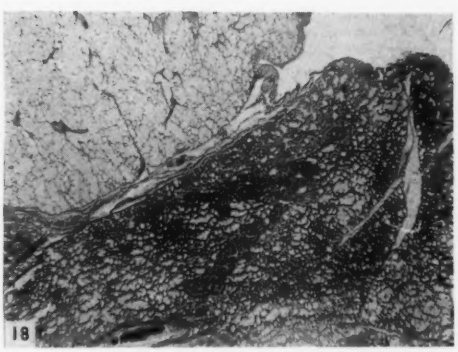


Fig. 13. #13 showing a fresh nodule, wih eosinophiles in the central dark part, surrounded by a zone of fibroblastic proliferation with agranulocytic infiltration and collateral hyperemia.

Fig. 14. #14 showing hyperplasia of the muscular layer of the bronchioles and the atalectasis and septal hyperplasia adjacent to the interlobular border due to the presence of eggs deposited along the path of an adult female traveling through the lung.

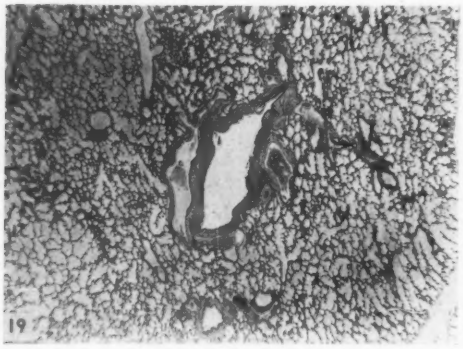
Fig. 15. #15 showing a healed nodule, composed of fibrous connective tissue, infiltrated with a few eosinophiles, encroaching on a bronchus.

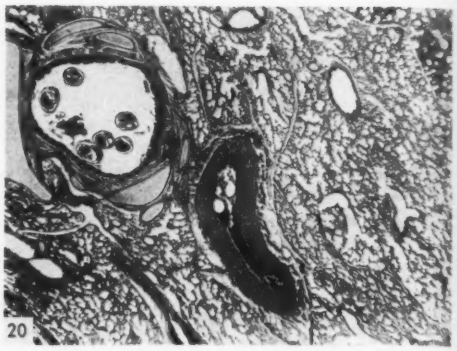
Fig. 16. #16 showing septal hyperlpasia, pleural thickening, emphysema and sub-pleural atalectasis.

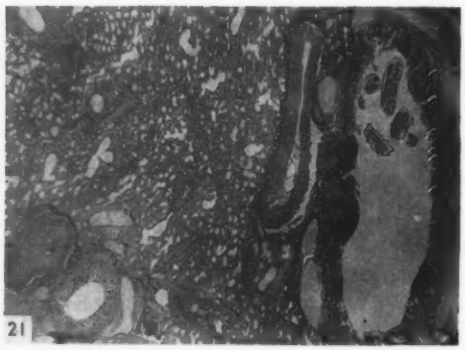
Fig. 17. #17 showing septal hyperplasia.

Fig. 18. #18 showing atalectasis in the lobule at the right due to the presence of *Protostrongylus* eggs and larvae and the consequent compensatory emphysema of the lobule at the left.

Magnification in each case is 6×.







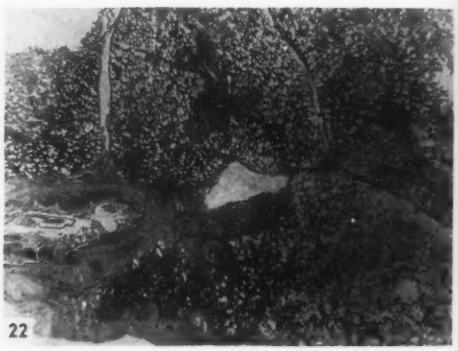


Fig. 19. #19 showing slight emphysema.

Fig. 20. #20 showing bronchus with six specimens of *Dictyocaulus*, scanty catarrhal exudate, and collateral hyperemia.

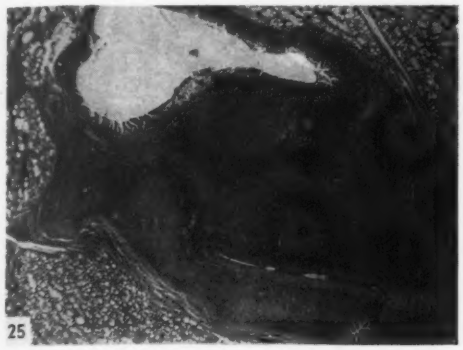
Fig. 21. #20 showing *Dictyocaulus* in bronchus, erosion of mucosa, lymphocytic infiltration of all bronchial layers, and hyperemia of adjacent pulmonary tissue.

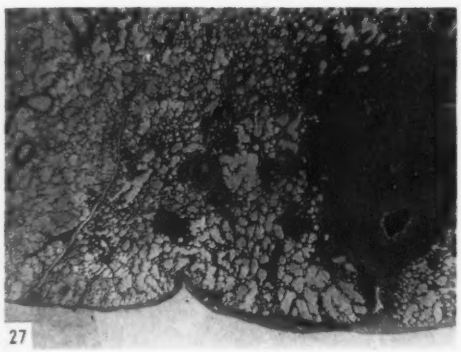
Fig. 22. #11 showing *Dictyocaulus* in bronchus, erosion of mucosa, more exudation but less infiltration than in Fig. 21.

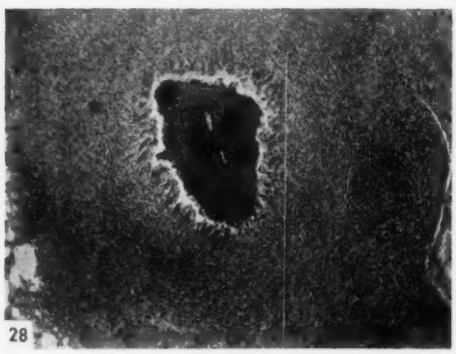
Fig. 23. #23 showing bronchus completely plugged with exudate resulting from reaction to presence of *Dictyocaulus*. Increased aggregation of lymphocytes and collateral hyperemia.

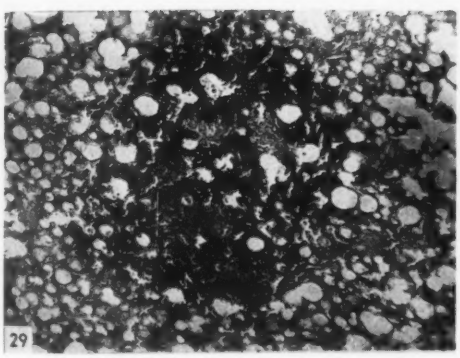
Fig. 24. #11 showing massive collapse which involved entire mediastinal lobe and was associated with the presence of thousands of *Protostrongylus* eggs and larvae.

Magnification in each case is 6×.









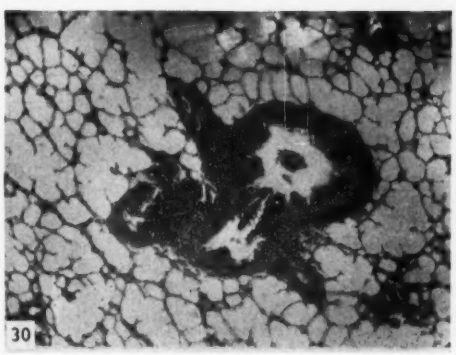


Fig. 25. #13 showing large nodule encroaching on a bronchus. Composed chiefly of fibrous connective tissue with scattered eosinophiles, with central portion of eosinophiles and lymphocytes surrounding remains of fourth stage *Protostrongylus* larva. Magnification is 6×.

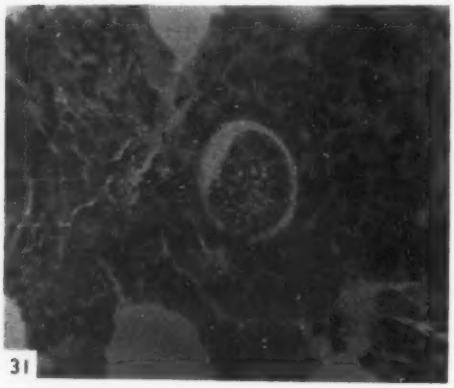
Fig. 26. #13 showing healing nodule with calcifying necrotic center, zone of epithelioid cells, and fibrous connective tissue capsule. Magnification is 30×.

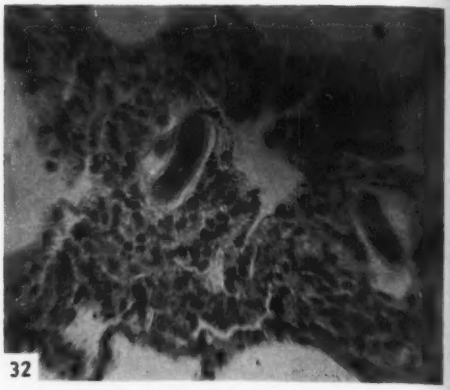
Fig. 27. #14 showing nodule, which is enlarged in Fig. 28, in region of bronchiolar proliferation similar to that in Fig. 10. Magnification is 6×.

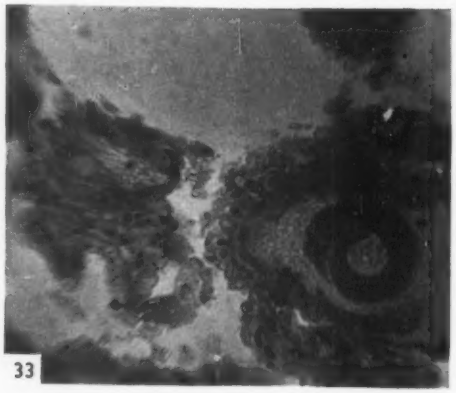
Fig. 28. Nodule of Fig. 27 enlarged to show fourth stage larva of *Protostrongylus* trapped in center by eosinophilic and lymphocytic reaction, surrounded by zone of radially arranged epithelioid cells, within a region of fibro-blastic proliferation, also containing both eosinophiles and lymphocytes. Magnification is 30×.

Fig. 29. Punctiform region of hemorrhage in lung of deer #12, indicating point where fourth stage larvae have broken through from the blood stream to enter the air spaces. Magnification is 30×.

Fig. 30. Hyperplasia of lymphoid tissue about a bronchiole. Magnification is 30×.







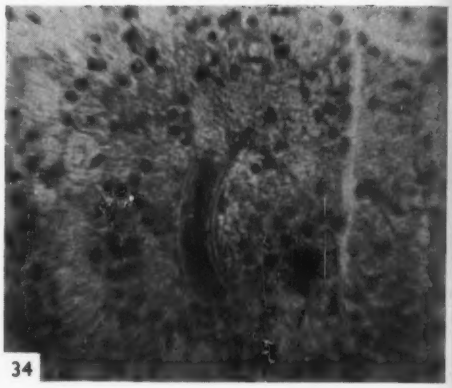


Fig. 31. #11 under high power showing *Protostrongylus* egg in early segmentation stage. Magnification is 120×.

Fig. 32. #11 under high power showing egg in later stage with embryonic larva. Magnification is 120×.

Fig. 33. Newly hatched larva in #6 surrounded by red blood cells in alveolus. Magnification is 120×.

Fig. 34. Catarrhal exudate in #11 in region of massive collapse under high power showing first stage larva surrounded by mucus and agranulocytic cells. Magnification is 120×.

Fig. 35. #18 showing a region of excessive lymphoid aggregation and proliferation in the presence of *Protostrongylus* larvae. Magnification is 6×.

Fig. 36. Caudal ends of the first stage larvae of three lungworms. Left to right: *Protostrongylus*, *Dictyocaulus*, *Muellerius* (after Mönnig). Magnification is about 120×.

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mediastinal lobe of this animal, which lobe showed massive collapse, complete plugging of all bronchi and bronchioles with catarrhal exudate, heavy agranulocytic infiltration of the lobe, the numbers of round cells increasing toward the bronchi and bronchioles. Close examination of these round cells showed most of them to be plasma cells.

The significance of plasma cells is not conclusively established, but they have been observed in a variety of chronic inflammatory conditions. Maximov (1928) says that they occur in varying proportions wherever there are aggregations of lymphocytes and monocytes and both he and Naegeli (1923) share the opinion that most plasma cells are modified lymphocytes. Osgood (1931) reports that he has never found any evidence of plasma cell development from lymphocytes and he believes that they are a separate and distinct line of cells.

Returning to the above deer, in which the entire mediastinal lobe was rendered functionless by collapse and infiltration, it should be said that the animal was shot and was apparently normal, and in good health so far as could be determined by its behavior and physical condition.

A confusing inconsistency in the text of Olt and Ströse (1914) and Nieberle (1924) should be pointed out in passing. In both works it has been correctly stated that members of the genus *Dictyocaulus* deposit embryonated eggs which hatch soon after laying. However in their discussions of lung strongylosis in roe deer, both authors refer to the presence of eggs in all stages of cleavage in lesions attributed to *Strongylus micrurus* (*Dictyocaulus viviparus*). Drawings, accredited to Joest, appear in Nieberle's article, showing chronic interstitial pneumonia and the presence of foreign-body giant-cells along with eggs in different segmentation stages up to worm embryos. There is also a figure of chronic pneumonia with septal hyperplasia and giant-cells in an ibex, with what appear to be segmenting eggs. Apparently, though species of *Dictyocaulus* are undoubtedly found in the roe and ibex, these figures and descriptions are of lungs infested with worms of the subfamily Protostrongylinae, for their pathology certainly tallies with what is known about the lesions of *Protostrongylus* and *Muellerius*, either of which genera they might be. These may of course, have been mixed infections, as we have found in deer, the larger *Dictyocaulus* being found grossly, and the eggs and larvae of the other worms appearing microscopically.

CHANGES IN THE LUNGS DUE TO DICTYOCAULUS VIVIPARUS

Attributable to Fourth Stage Larvae. So far as can be determined the process of breaking out of the blood stream into the air spaces is accomplished in a manner similar to that described for *Protostrongylus coburni*. Inasmuch as fewer numbers of *Dictyocaulus* than *Protostrongylus* invade the deer lungs, those animals which are only infected with *Dictyocaulus*, show only minute petechial hemorrhages or pigmented points representing old petechiae, never large areas of bleeding. Figure 29 illustrates one of these regions.

The formation of nodules about fourth stage larvae and young adults, such as is observable in *Protostrongylus* infections in deer and *Muellerius* infections

in sheep, has not been noted with respect to *Dictyocaulus* in deer.

Attributable to Adults. Most of the worms occur in the medium-sized bronchi, but they may be in the smaller ones, down as far as the point where the cartilages disappear. They are found in much fewer numbers than in domestic animals, where they sometimes occur in the larger bronchi and trachea also. The largest number found during these studies was about fifteen (in deer #20). They lie parallel to the axis of the bronchus and several may be found side by side. The bronchus illustrated in Figure 20 shows six worms thus disposed while that shown in Figure 12 contained seven similarly arranged.

The reaction of the host tissue to the parasites varies considerably, ranging from a condition in which the presence of seven adults in the same location in a bronchus apparently provoked no response (Figure 12) to that in which the bronchus is completely plugged by catarrhal exudate and eosinophile cells, in response to only two worms (Figure 23). Between these extremes are a number of stages and an attempt has been made to describe them in their correct chronological relationship.

The first response to the presence of adults seems to be the formation of a scanty catarrhal exudate, during the formation of which the mucosa and submucosa appear to swell slightly, the latter becoming edematous and congested, as Figures 20, 21, and 22 show. As exudation progresses, bronchial epithelium is cast off into the lumen forming a greater and greater proportion of the exudate. As this goes on, eosinophiles gather in the lumen, mucosa, and submucosa. Peribronchial lymphoid tissue, where present, becomes hyperplastic.

As the bronchus approaches the condition shown in Figure 23, in which it is occluded by the exudate, collateral changes take place, including hyperemia of the neighboring alveolar walls, atalectasis due to the exclusion of air from the lobules dependent on the involved bronchus, and compensatory emphysema bordering the collapsed portions.

The changes in the bronchioles and lungs tend to be secondary to those in the bronchi, where the adults usually reside, inasmuch as in none of the cases that I have studied have embryonated eggs or newly hatched larvae been found either in the bronchi in which adults are present or in the bronchioles or pulmonary tissue dependent on those bronchi.

INCIDENCE AND IMMUNITY

Analysis of the findings in the eighteen deer shot on the George Reserve follows: (*Dictyocaulus* data omitted.)

Total number of deer	18
Protostrongylus eggs present	10
Eggs absent but nodules present	3 (#12, #13, #15)
Interstitial changes suggesting previous infection	2 (#7, #17)
No present or past infection	3 (#8, #19, #20)

Current infection with egg-laying adults is indicated by the presence of the eggs and first stage larvae, and in this series the percentage of such infection is 55. Though this series was considered to be a random and representative sample of the deer on the George Reserve it was not large enough a group to allow adequate analysis on the basis of age classes.

Through the courtesy of Dr. E. C. O'Roke, access has been had to records on one hundred and ninety-six deer, some taken by shooting, some found dead, from scattered areas in all parts of Michigan where deer are found. Most of the lungs of these animals were examined by Dr. O'Roke, although a number of them were available to me.

In the consideration of possible reasons for the lower lungworm incidence in the older animals the following questions come to mind:

1. Do the food habits of the younger deer differ from those of the older animals to such an extent that there is less chance of ingestion of infective larvae as age increases?

TABLE 2

Age class		Protostrongylus		Dictyocaulus	
		Number	%	Number	%
Fawns found dead	19	17	89		
Total fawns	57	41	72	5	8.7
Fawns shot	38	24	63		
Yearlings	19	10	53	1	5.3
Adults	107	45	42	4	3.7
Senile	13	4	31	0	0.0
Totals and averages	196	100	51	10	5.1

Evidence of infection was determined by scraping the surfaces of the smaller bronchi and finding the first stage larvae of *Protostrongylus*. Adults of the genus *Dictyocaulus* were of course obvious when the bronchi had been split down to their ends.

The following table (Table 2) shows the results of these examinations, according to the ages of the deer, as nearly as could be determined by sizes, weights, etc.

It will be noted from the above table that the *Protostrongylus* incidence of 51% over the State is comparable to the 55% found on the George Reserve. The fact that the incidence is lower in the older animals is also apparent both for *Protostrongylus* and *Dictyocaulus*. A striking difference between the lungworm incidence in fawns found dead and those collected by shooting is manifest.

2. Does so-called age-imnimuty develop?

3. Does acquired immunity appear as a result of infection, and if this is likely, what may its mechanism be?

Observers of the food habits of deer report no differences between the food selected and eaten by fawns and that consumed by adults. After weaning, the fawns travel with the does and apparently eat the same vegetation, as do the older animals. If lungworm infections are contracted by feeding in low, moist places as is the case with both the genera involved in this study, the adults stand as great a chance of picking up the parasites as do the fawns.

To prove or disprove age immunity, considerable experimental work would be necessary, involving the rearing of a number of animals and the establishment of the life cycle of the worm to procure infective larvae. Similarly, in

order to interpret adequately the significance of active acquired immunity, animal experimentation would be required. Opportunities for carrying on this kind of work have not been afforded.

However, it is possible to point out the apparent role of certain cellular reactions in immunity to lungworms. Taliaferro (1934) remarked on the inadequacy of studies of the essential cellular basis of acquired immunity to metazoans. Kerr (1936) reviewed some of the previous works pertaining to this subject, which, with his own investigations of immunity to dog hookworm in mice, led him to conclude that the activity of polymorphonuclears and macrophages, dependent on humoral antibodies, was the chief mechanism of immunity to nematodes.

The organs, in which this process operates to prevent the completion of the life cycle, would be expected to be different with different parasites, depending on their portals of entry and other characteristics of their modes of life. Thus, in hookworm infections, there may be marked skin reactions in immune animals and no retention of larvae in the lungs, while with lungworms, the mesenteric lymph nodes, which lie in the path of migration may be reactive and walling off of fourth stage larvae in the lungs is not uncommon.

The encysting of a fourth stage larva in a mesenteric node in #13 has been mentioned and the formation of nodules around the larvae as they reach the lungs and are embolized has been described. It should be noted that nodules such as these have have not been observed to be associated with *Dictyocaulus*, this type of reaction apparently being provoked only by the Protostrongylinae.

A survey of the literature showed reports on immunity to lungworm infections to be largely confined to observations incidental to life history and ecological studies on *Dictyocaulus*. Schmid (1936) reviewed some of this work and reported from his experience that no immunity to *D. viviparus* developed in cattle, in contrast to the finding of Kauzal (1933, 1934) in sheep with *D. filaria*.

SUMMARY

Studies on the microscopic changes in the tissues of twenty northern white-tailed deer, fourteen of which had natural lungworm infections, revealed the following:

1. The changes attributable to infestation with worms of the genus *Dictyocaulus* are chiefly due to the presence of the adults in the bronchi. The reaction is confined to local regions of bronchitis and peribronchitis.

2. Heavy infestations with *Dictyocaulus*, such as are found in domestic animals, with their accompanying serious effects, have not been observed.

3. The most significant changes attributable to *Protostrongylus coburni* infestation are due to the presence of eggs and newly hatched larvae in the alveoli.

4. The extensive lymphocytic reaction to the presence of these eggs and larvae is accompanied by collapse and interstitial pneumonia of the infected regions, which often comprise large parts of the lung.

5. Other changes due to *Protostrongylus coburni* consist of nodular lesions resulting from the entrapping of the

fourth stage larvae as they arrive from the blood stream. These larvae are encircled by eosinophils and agranulocytes, the focus becoming walled off from the surrounding lung by fibroblastic proliferation. The lesions are localized and eventually scar or calcify.

6. It is suggested that the encasing of the fourth stage larvae in the nodules in the lungs and mesenteric lymph nodes is a mechanism of immunity to lungworms of the genus *Protostrongylus*, as it operates to prevent the completion of the life cycle of the parasite.

7. The relationships between the various factors implicated in winter losses of deer, i.e. lungworms, bacteria, malnutrition, and exposure, are still incompletely understood, further knowledge of the normal and pathological flora of the lungs being needed to correlate with data thus far obtained. The high coincidence of lungworms and winter losses seems to indicate more than a chance relationship.

BIBLIOGRAPHY

AYNAUD, M.
1926. Origine vermineuse du cancer pulmonaire de la Brebis. Compt. Rend. Soc. Biol. 95 (38): 1540–1552.

BLOOM, W.
1937. Transformation of lymphocytes into granulocytes in vitro. Anat. Rec. 69 (1): 99–121. 2 pl.

CORYLOSS, and BIRNBAUM.
1929. Lobar pneumonia considered as pneumococcic lobar atelectasis of the lungs. Arch. Surg. 18: 190–241.

DAUBNEY, R.
1920. The life histories of *Dictyocaulus filaria* (Rud.) and *Dictyocaulus viviparus* (Bloch). Journ. Comp. Path. & Ther. 33: 225–266.
1922. The lesions in lungworm disease ("husk" or "hoose") in cattle. Journ. Comp. Path. & Ther. 35: 108–117.

DIKMANS, G.
1934. Lungworms collected from deer, *Odocoileus virginianus*, in Michigan. Proc. Helm. Soc. Wash 2 (1): 59.
1935. Two new lungworms, *Protostrongylus coburni* n. sp. and *Pneumostrongylus alpenae* n. sp. from the deer, *Odocoileus virginianus*, in Michigan. Trans. Amer. Micr. Soc. 54: 138–144.

HOBMAIER, A. and M.
1929. Ueber die Entwicklung des Lungenwurmes *Synthetocaulus capillaris* in Nackt-, Weg-, und Schnirkelschnecken. Muench. Tieraertzl. Wochenschr. 80 (36): 497–500.
1929. Die Entwicklung des Lungenwurmes des Schafes, *Dictyocaulus filaria* Rud. ausserhalb und innerhalb des Tierkorpers. Muench. Tieraerztl. Wochenschr. 80 (45): 621–624. 9 fig.
1930. Life History of *Protostrongylus* (*Synthetocaulus*) *rufescens*. Proc. Soc. Exp. Biol. & Med. 28: 156.
1930. *Limax* und *Succinea*, zwei neue Zwischenwirte von *Muellerius* (*Synthetocaulus*) *capillaris* des Schafes und der Ziege. Muench. Tieraeztl. Wochenschr. 81 (23): 285–287.
1934. *Elaphostrongylus odocoilei* n. sp., a new lungworm in black-tail deer (*Odocoileus columbianus*). Description and life history. Proc. Soc. Exp. Biol. & Med. 31 (4): 509–514.

HOBMAIER, M.
1934. Lungenwurmlarven in Mollusken. Zeitschr. f. Parasitenk. 6: 642–648.
1934. Metamorphosis of *Metastrongylus* larvae in mesenteric lymph glands. Arch. Path. 17 (6): 769–774.

JOEST, E.
1908. Zur pathologischen Anatomie der Lungenkrankheit (Lungenstrongylose) des Rindes. Zeitschr. Infekt. Krank. Haustiere 4 (3/4): 201–215.

KAUZAL, G.
1933. Observations on the bionomics of *Dictyocaulus filaria* with a note on the clinical manifestations in artificial infections in sheep. Austral. Vet. Journ. 9 (1): 20–26.
1934. Observations on the development of resistance to *Dictyocaulus filaria*. Austral. Vet. Journ. 10 (3): 100–111.

KERR, K. B.
1936. Studies on acquired immunity to the dog hookworm, *Ancylostoma caninum*. Amer. Journ. Hyg. 24 (2): 381–406.

MARSH, H.
1938. Pneumonia in Rocky Mountain Bighorn Sheep. Journ. Mammal. 19 (2): 4–219.

MAXIMOV, A.
1928. Lymphocytes and Plasma cells. Special Cytology, Hoebner, N. Y.

M'FADYEAN, J.
1894. Verminous Pneumonia in the Sheep. Journ. Comp. Path. and Ther. 7: 31–42. 2 pl.

MÖNNIG, H. O.
1938. Veterinary Helminthology and Entomology. Wm. Wood. & Co., Baltimore, Md. 2nd edit.: 409 pp.

NAEGELI, O.
1923. Blutkrankheiten und Blutdiagnostik. J. Springer, Berlin, 4th edit.

NIEBERLE, K.
1924. Atmungsorgane. E. Joest's Spez. Path. Anat. d. Haustiere. Berlin. 3 (2): 555–853. 3 pls., figs. 268–477.

NUNGESTER, W. J. and JOURDONAIS, L. F.
1936. Mucin as an aid in the experimental production of lobar pneumonia. Journ. Inf. Dis. 59 (3): 258–265.

NUNGESTER, W. J., JOURDONAIS, L. F. and WOLF, A. A.
1936. The effect of mucin on infections by bacteria. Journ. Inf. Dis. 59 (1): 11–21.

OLT, A. and STRÖSE, A.
1914. Die Wildkrankheiten und ihre Bekampfung. J. Neumann, Neudamm. 633 pp.

O'ROKE, E. C.
1936. The Lungworm situation in the White-tailed Deer (*Odocoileus virginianus borealis*) in Michigan. Proc. No. Amer. Wildlife Conf. 1: 473–478.

OSGOOD, E. E. and ASHWORTH, C. M.
1937. Atlas of Hematology, J. W. Stacey, Inc., San Francisco. 255 pp., 325 figs.

POTTS, M. K.
1938. Observations on Diseases of Bighorn in Rocky Mountain National Park. Trans. No. Amer. Wildlife Conf. 3: 893–897.

SCHMID, F.
1936. Zur Frage der Immunität bei parasitären Krankheiten und ihrer Bedeutung für die Bekämpfung. Zeitschr. Infekt. Krank. Haustiere. 49: 177–207.

SHAW, J. N.
1934. Lungworms (*Dictyocaulus filaria* Rudolphi) in sheep and goats. Oregon Agr. Exp. Stat. Bul. 327: 12 pp.

TALIAFERRO, W. A.
1934. Some cellular bases for immune reactions in parasitic infections. Journ. Parasit. 20 (3): 149–161.

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HUNTING RECORDS FOR THE PRAIRIE FARM, SAGINAW COUNTY, MICHIGAN, 1937–1939

R. D. Burroughs and Laurence Dayton

The Prairie Farm Project consists of 8,956 acres of low, level land. Approximately 8,400 acres are isolated by the Flint and Shiawassee Rivers and a system of canals and dikes. The Michigan Department of Conservation has cooperated with the Farm Security Administration during the past three years in a controlled hunting program involving the isolated portion of the project.

No attempt was made to restrict the hunting in this area, since primary objectives would have been encumbered by curtailment of the hunting pressure. Keeping the area open enabled us to accumulate data on the productivity of the land in terms of the annual "crop" of pheasants and rabbits available for harvest; to observe effect of heavy hunting on these species; and to evaluate the project as a unit of hunting range.

"Control" in case of this project has involved the registration of all hunters, and the recording of such data as the hunters have been able to furnish. To facilitate accuracy, each hunter has been issued a permit on which space has been provided for recording the desired information. A complete check-up at the end of the day has disclosed the names of any hunters who failed to return their permits, and all delinquents have been advised by mail to make their report on a duplicate permit.

The hunting public has cooperated in a satisfactory manner, and the records are more complete than might be expected. Each year a few reports of hunters getting into the area without permits have come to our notice, but a careful patrol has been maintained and only three hunters without permits have been apprehended. Violations of game laws have been rare. Occasionally an abandoned hen pheasant has been picked up in the field, but only one individual has been apprehended with illegal game in possession. A few arrests, however, have been made on the project for carrying loaded guns in automobiles.

Kill Records and Success Ratios

The annual harvest of pheasants and rabbits on the Prairie Farm has increased each season. In 1938 the pheasant kill jumped from 616[1] to 1,244 male birds. This increase was undoubtedly due to the sharp rise (72%) in hunting pressure (Tables 1, 2, and 3). The pheasant kill in 1939, however, showed only a 6% increase in spite of a 34% increase in hunting pressure.

The pheasant kill per unit-area in 1938 and 1939 seemed to depend upon the shootable population in the area rather than the degree of hunting pressure. The fact that the kill per square mile remained approximately constant (94 and 101) in 1938 and 1939, despite the 28% increase in the number of hunt-

[1] Complete records for 1937 were published in The Journal of Wildlife Management, vol. 3, pp. 19–25.

ers and five more days of hunting, seems to indicate that we cannot expect this area to yield a significantly greater number of cock pheasants without a definite improvement in the habitat. Unless the carrying capacity of the land is improved, the annual harvest can be expected to remain at approximately 100 cock pheasants per square mile.

Data taken from the game-kill reports required of all licensed hunters in Michigan indicate that the Prairie Farm has produced a larger pheasant kill per square mile than either Saginaw County or Michigan's pheasant range considered as a whole.[2] In 1937 the kill on the Prairie Farm was 47 cock pheasants per square mile; in Saginaw county, 49 per square mile; in the state at large, 41 per square mile. In 1938 the kill for the Prairie Farm was 94 per square mile; in Saginaw county, 58 per square mile; and for the entire pheasant range, 48 per square mile. Data from the compulsory game-kill reports for 1939 are not yet available.

In view of the fact that no food or cover management has been practiced on the Prairie Farm this high degree of productivity in terms of cock pheasants for the hunter seems remarkable. Stocking with artificially propagated birds has been limited to one release of 100

TABLE 1

SIGHT RECORDS AND KILL OF PHEASANTS AND RABBITS ON THE PRAIRIE FARM DURING THE 1938 SEASON

Date	Number of permits issued	Number of hunters per day reporting	Gun-hours per day	Game reported seen			Game killed	
				Pheasants		Cotton-tails	Pheasant cocks	Cotton tails
				Hens	Cocks			
Oct. 15	709	687	3,093	5,828	4,284	478	467	77
16 (Sunday)	837	816	2,601½	3,291	1,868	224	230	29
17	130	123	307½	290	187	17	28	1
18	89	82	180½	155	85	14	27	4
19	96	95	311¾	907	359	31	36	6
20	97	91	202½	216	95	13	19	2
21	109	106	338¾	825	318	36	44	6
22	361	360	1,560½	3,950	1,422	148	115	35
23 (Sunday)	431	425	1,615	3,974	1,200	154	91	32
24	69	69	273½	539	159	26	19	9
25	52	50	156½	406	90	9	14	4
26	99	95	328	907	284	25	24	6
27	63	61	198½	461	210	19	23	1
28	62	62	227½	697	192	18	15	3
29	324	309	1,283½	1,107	459	120	43	28
30 (Sunday)	353	348	1,183½	956	199	120	30	31
31	53	52	165½	335	72	16	4	6
Special permits	5	5	41	187	72	7	15	—
Totals	3,939	3,836	14,068⅓	25,031	11,555	1,475	1,244	280

[2] Michigan's pheasant range consists of approximately 12,000,000 acres of land situated south of the North line of *T*16N. The kill records for the territory south of this boundary are used as a basis for estimating the kill per square mile of pheasant range.

TABLE 2

SIGHT RECORDS AND KILL OF PHEASANTS AND RABBITS ON THE PRAIRIE FARM DURING THE 1939 SEASON

Date	Number of permits issued	Number of hunters per day reporting	Gun-hours per day	Game reported seen			Game killed	
				Pheasants		Cotton-tails	Pheasant cocks	Cotton-tails
				Hens	Cocks			
Oct. 15 (Sunday)	1,682	1,672	8,285	20,187	10,382	919	669	138
16	133	133	427¾	1,011	268	27	30	5
17	118	118	396½	1,077	328	11	39	2
18	127	127	433	1,342	342	43	48	4
19	87	87	243	438	127	5	14	1
20	138	138	500½	943	267	14	33	2
21	421	421	1,985½	5,881	1,669	176	112	33
22 (Sunday)	770	770	2,953½	6,467	1,416	248	134	46
23	50	50	161½	455	51	1	9	4
24	38	38	102¾	452	86	2	15	0
25	66	66	219	595	90	15	6	2
26	57	57	193¾	569	121	14	16	3
27	76	75	227½	751	90	17	6	1
28	244	244	1,140	3,213	550	118	48	22
29 (Sunday)	402	399	1,472	3,399	526	129	36	27
30	18	18	65½	372	18	17	3	1
31	13	13	37¾	119	9	2	3	1
Nov. 1	36	36	125	1,175	55	7	7	3
2	23	22	86¾	392	67	5	4	2
3	42	42	197½	1,091	130	22	10	7
4	197	197	883	2,631	326	61	32	14
5 (Sunday)	318	318	1,344¼	3,199	382	108	44	11
Totals	5,056	5,041	21,481	55,759	17,300	1,961	1,318	329

cock pheasants on July 16, 1939, and a few unsexed birds raised by 4-H Club boys on the project. These releases cannot be considered significant. A legal kill of 101 male ring-necks per square mile probably cannot be duplicated in many unmanaged areas east of the Mississippi.

The first Saturday and Sunday of the "open" season are significant days for the pheasant hunter on the Prairie Farm. 52% of the pheasant kill occurred on Friday, Saturday and Sunday in 1937; 56% on Saturday and Sunday in 1938; and 50.8% on Sunday in 1939.[3]

[3] Pheasant season in Michigan opens on Oct. 15: this date fell on Friday in 1937: Saturday in 1938; Sunday in 1939.

The distribution of the pheasant kill through successive days of the three seasons is presented in Fig. 1. Upon examination of this graph, the stature of the kill on the first "week-end" assumes impressive proportions, and the lesser importance of the succeeding days of the season becomes apparent. Approximately 66% of the pheasant kill has consistently been made during the first week of the season, and 80% of the kill has been made by Monday of the second week.

A number of sportsmen have questioned the wisdom of extending the pheasant season in 1939. This criticism was based on the assumption that five more days of hunting would reduce the

number of cock birds to such an extent that the sex-ratio would be seriously disturbed. The records indicate that the kill during the extra five days amounted to only 7.3% of the total. It seems safe to assume that the pheasant kill throughout Michigan's entire pheasant range follows the same pattern, and that the bulk of the kill occurs early in the season. All of the evidence points to the fact that the "longer" season in 1939 was of small consequence.

The kill per gun-hour has been low in spite of the high kill per unit-area. This situation can be attributed to excessive hunting pressure, but the occurrence of extensive tracts of heavy cover has been a contributing factor. The data (Table 4) indicate that the chances of shooting a pheasant have been best when few hunters were in the field.

SIGHT RECORDS AS AN INDEX OF THE PHEASANT SEX-RATIO

Sight records have been used as a basis for estimating the sex-ratio of the pheasant population. The limitations of such data are recognized, but the following figures are offered for what they may be worth. Observations are probably most significant the first days of the season before too large a proportion of the cocks have been killed. Records for the first week-end in 1937 indicated a ratio of one cock to 1.5 hens; in 1938, one cock to 1.5 hens; and in 1939, one cock

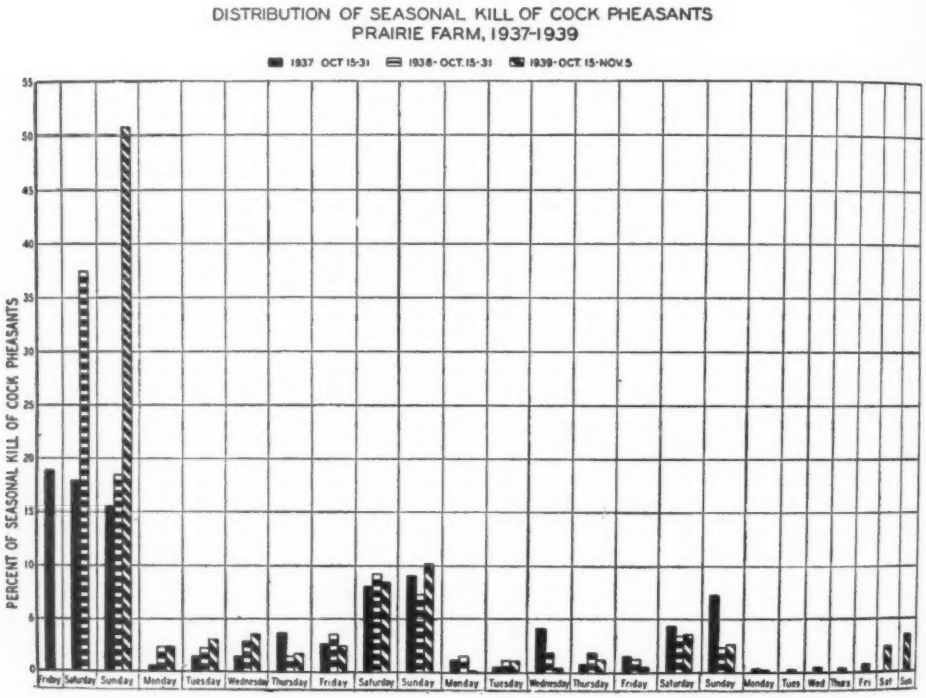

Figure 1

to 1.9 hens. Using the season totals as a basis for calculation, the ratio of cocks to hens was 1:1.9 in 1937; 1:2.1 in 1938, and 1:3.2 in 1939.

While we recognize that these calculations are based on figures which in many cases involved approximations of the numbers of cocks and hens actually seen, the data nevertheless seem to indicate that the sex-ratio was not affected adversely by the heavy hunting in 1938. Observations made during the past winter indicate that a sufficient number of cocks survived the 1939 hunting season and the vicissitudes of the winter to meet the demands of spring breeding.

HUNTING PRESSURE

The hunting pressure on the Prairie Farm has increased each year. Eighty per cent more permits were issued in 1938 than in 1937, and 28% more in 1939 than in 1938. No limitations have been placed on the number of permits issued per day or per season. Since there is no indication that too large a proportion of the pheasant population has been killed we see no necessity for changing this policy. A better distribution of the hunting pressure, however, would have been desirable since the project was over-crowded on Saturdays and Sundays. Limiting the hunting on these days

TABLE 3

SUMMARY OF DATA ON PHEASANT AND RABBIT HUNTING PRAIRIE FARM, 1937–1939

A. *Hunting Pressure*

Year	Number of days	Hunters per season	Gun-hours per season	Average number hunters per day	Average number hunters per sq. mile per day
1937	17	2,181	8,168	128	10
1938	17	3,836	14,068	225	17
1939	22	5,041	21,481	229	17

B. *Pheasant Kill Records*

Year	Number of days	Total kill (cocks)	Kill per square mile	Kill per hunter	Kill per gun-hour
1937	17	616	47	.28	.075
1938	17	1,244	94	.32	.088
1939	22	1,318	101	.26	.061

C. *Kill Records for Rabbits, and Other Species*

Year	Number of days	Total Kill		
		Rabbits	Squirrels	Ducks
1937	17	71	(Season closed)	(Not recorded)
1938	17	280	(Season closed)	(Not recorded)
1939	22	329	32	43

would not have remedied the situation; it would only have reduced the season's total of hunters using the area.

The demand for hunting areas of this type which afford freedom from trespass difficulties can be illustrated by citing several hundred men were waiting for the doors to open. Twelve hundred permits had been issued by 8:00 A.M. and the day's total reached 1,682, which is equivalent to 128 hunters per square mile, or one hunter for each five acres of land.

TABLE 4

HUNTING SUCCESS RATIOS

Gun-hours per day and kill per gun-hour (Pheasants)

	Oct. 15–31, 1937		Oct. 15–31, 1938		Oct. 15–Nov. 5, 1939	
	Gun-hours per day	Cocks killed per gun-hour	Gun-hours per day	Cocks killed per gun-hour	Gun-hours per day	Cocks killed per gun-hour
Friday	782	.15	—	—	—	—
Saturday	1,358½	.08	3,093	.01	—	—
Sunday	1,527	.06	2,601½	.08	8,285	.08
Monday	18½	.16	307½	.09	427¾	.07
Tuesday	116	.07	180½	.15	396½	.10
Wednesday	86½	.09	311¾	.11	433	.11
Thursday	223	.10	202½	.09	243	.05
Friday	304½	.05	338¾	.13	500½	.07
Saturday	753	.06	1,560½	.07	1,985½	.05
Sunday	907	.06	1,615	.05	2,953½	.04
Monday	52½	.15	273½	.07	161½	.05
Tuesday	70	.04	156½	.09	102½	.12
Wednesday	183½	.13	328	.07	219	.12
Thursday	96	.05	198½	.11	193¾	.08
Friday	128	.07	227½	.06	227½	.02
Saturday	619½	.04	1,283½	.03	1,140	.04
Sunday	942½	.05	1,183½	.02	1,472	.02
Monday	—	—	165½	.02	65½	.04
Tuesday	—	—	—	—	37¾	.08
Wednesday	—	—	—	—	125	.05
Thursday	—	—	—	—	86¾	.04
Friday	—	—	—	—	197½	.05
Saturday	—	—	—	—	883	.03
Sunday	—	—	—	—	1,344¼	.03
Total Gun-hours	8,168		14,068½		21,481	
Average Kill per Gun-hour		.075		.088		.061

our experience at the registration headquarters on the opening day in 1939.

The season opened officially at 7:00 A.M. October 15. We had planned to open the registration at 5:00 A.M., but at 4:00 A.M. a dozen or more men were already in line, in front of the registration headquarters, and by 5:00 A.M. Heavy shooting continued through the morning and a large part of the day's kill (669 cock pheasants and 138 cottontails) was made before 10:00 A.M. Obviously, this unusual concentration of hunters was undesirable, and too large a proportion of the season's kill was made on the opening day, but since

the opening of the season will not again fall on Sunday for several years, it seems unlikely that the difficulty will recur soon.

INFLUENCE OF AGRICULTURAL DEVELOPMENT

A system of farm tenancy has been introduced by the Farm Security Administration. The separate fields are tilled by farmers who reside in the vicinity of the project. Under this system of management, agriculture has prospered and many abandoned fields have been brought back under cultivation. In 1937 only 31% of the project area was farmed; but in 1939 70% of the land was under cultivation. These changes in the cover type percentages are illustrated in the accompanying map. (Fig. 2; and summarized in Table 5).

TABLE 5
VARIATION IN THE COVER TYPES ON THE PRAIRIE FARM
(1937–1939)

	Percentage		
Cover Type	*1937*	*1938*	*1939*
Cultivated fields	31	43	70
Pasture	9	3	1
Heavy weeds and light brush	33	27	11
Heavy brush	14	14	5
Woodlots	7	7	7
Dikes and canals	6	6	6

Fall plowing appears to be an important factor in limiting the supply of winter food. A few corn fields, however are generally left unplowed, and the pheasants use them extensively. During the recent winter they have also made excellent use of the discarded crowns of sugar beets which they find in the fields. The parenchymatous tissues are consumed and the fibrous "shells" are left as evidence of this activity. The importance of the sugar beet as a source of nourishment for pheasants, however, requires further investigation.

There is a good deal of evidence that pheasants on the area have depended largely upon the fruits of natural vegetation for nourishment. The achenes of the giant rag-weed (Ambrosia), beggar-ticks (Bidens), and burdock (Arctium) have been, and still are, of major importance. Whether the residues of cultivated crops will be sufficient to off-set the diminishing stands of these weeds remains to be seen.

If food becomes scarce, the birds can be expected to move out into adjacent areas during the winter months. The summer and fall populations, however, should remain about the same as in the past despite these seasonal migrations. The abundance of food and cover during the summer and autumn, combined with population pressure in the heavily stocked habitats on the outside, can be expected to insure a good breeding population on the project area regardless of the changes that are taking place. In any case there is no evidence that the carrying capacity of the land has been impaired during the past three years. Kill records during the period indicate that the productivity with respect to pheasants has remained nearly constant.

HUNTERS BENEFITED

A complete check of the permits for the recent season has disclosed the fact that 94% of the hunters came from four counties (Genesee, Saginaw, Wayne and Oakland) in eastern Michigan having large industrial centers of population; 46% were from Flint; 20% from Saginaw; 8% from Detroit; and approximately 2% from Pontiac. Eighteen per

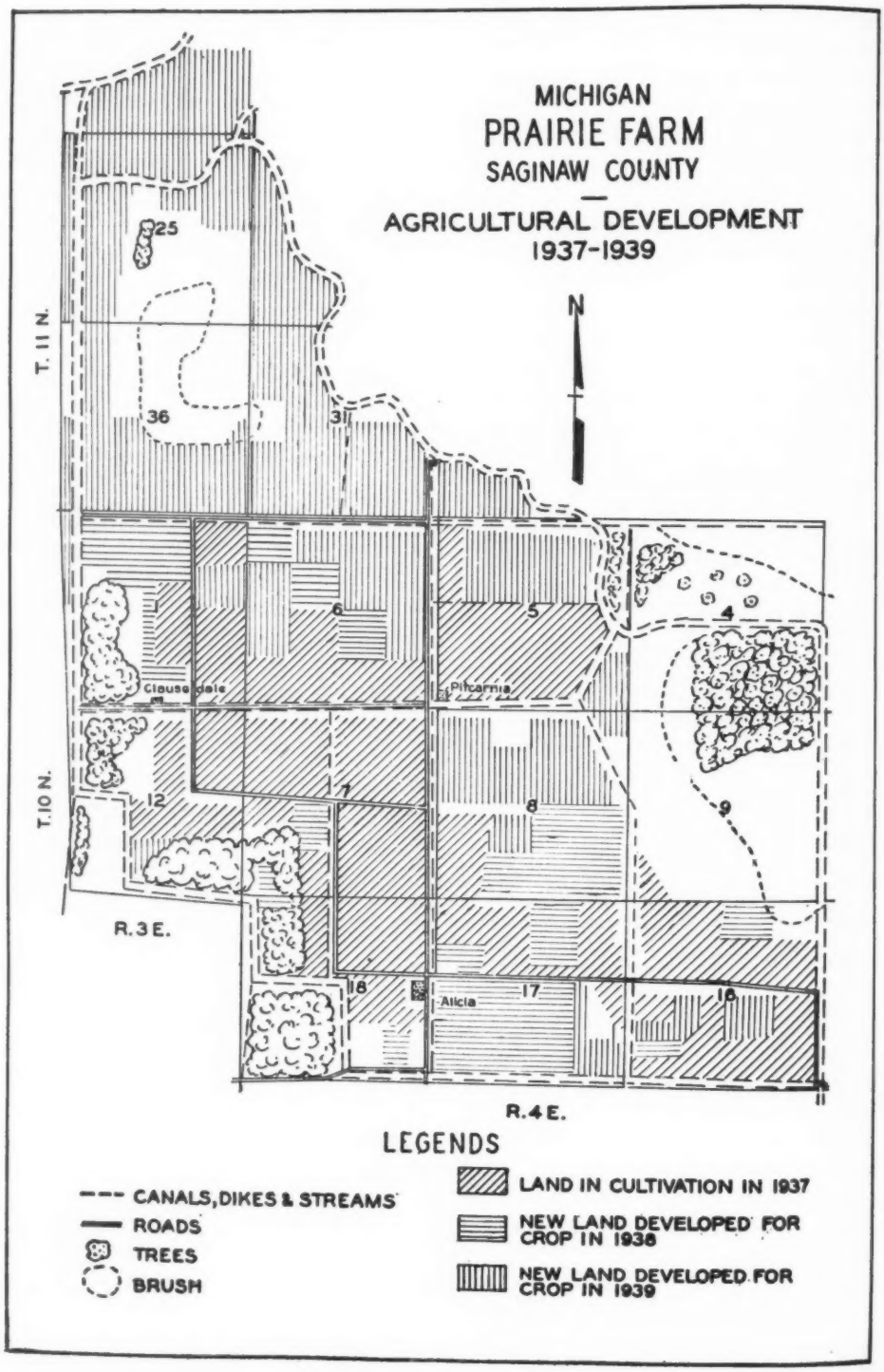
MICHIGAN
PRAIRIE FARM
SAGINAW COUNTY
AGRICULTURAL DEVELOPMENT
1937-1939
N
T. 11 N.
T. 10 N.
R. 3 E.
R. 4 E.
Clausedale
Pitcarnia
Alicia
LEGENDS
CANALS, DIKES & STREAMS
ROADS
TREES
BRUSH
LAND IN CULTIVATION IN 1937
NEW LAND DEVELOPED FOR CROP IN 1938
NEW LAND DEVELOPED FOR CROP IN 1939

Figure 2

cent were from villages and rural communities in these counties. The remaining 6% were from widely scattered communities in lower Michigan.

It is evident that this project is serving a group of hunters who often have difficulty in gaining access to private land. It is an area where the "city feller" can hunt without interference or embarrassment regardless of his occupation, creed, or color.

SUMMARY

1. The Michigan Department of Conservation has obtained accurate hunting records on 8,400 acres of isolated farm and waste land located in Saginaw county during a three-year period—1937–1939.

2. The hunting pressure has increased each year. In 1937 a total of 8,168 gun-hours was spent in the field; in 1938, 14,068; and in 1939, 21,481.

3. The seasonal kill of pheasants has increased, but not in the same ratio as the hunting pressure. In 1937, 616 cock pheasants were killed; in 1938, 1,244; and in 1939, 1,318.

4. The kill of cock pheasants per square mile in 1937 was 47; in 1938, 94; and in 1939, 101. In 1938 and 1939 the pheasant kill per square mile was approximately twice as great on the project area as in Saginaw county, or Michigan's pheasant range considered as a whole.

5. 66% of the pheasant kill has been made during the first week of the season, and 80% by Monday of the second week.

6. The high kill per unit-area does not appear to have seriously disturbed the pheasant sex-ratio or affected the productivity of the area.

7. Reduction in the amount of undeveloped land due to agriculture does not appear to have had any pronounced effect on the productivity of the project so far as pheasants are concerned. Whether food and cover conditions have been improved, or not, remains to be seen.

8. 76% of the hunters using the project in 1939 were from four principal cities in eastern Michigan. Since the trespass problem is acute on private land within reasonable driving distance from these cities, the project has been worthwhile from the standpoint of public relations as well as game management.

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PRODUCTION OF PHEASANTS IN NORTH-CENTRAL IOWA IN 1939[1]

Thomas S. Baskett

Since its inception in the autumn of 1935, the research program of the Iowa Cooperative Wildlife Research Unit has included life history and management studies of the ring-necked pheasant (*Phasianus colchicus torquatus*) on the Winnebago Experimental Area. During the first three years emphasis was placed on study of winter survival and cover development (Green and Beed, 1936; Green, 1938, and unpublished reports), but in 1939 special attention was directed to the reproductive phase of the pheasant's life cycle.

Here are reported data gathered on the Winnebago Area, in north-central Iowa, from March until September, 1939. The research was under Dr. George O. Hendrickson, Iowa State College, and Thomas G. Scott, United States Bureau of Biological Survey.

Methods

A plot of 1,520 acres, continuous, but irregular in shape and lying in five sections, was chosen for intensive investigation.

Nests were found by repeated systematic hunting through the fields, and the findings were checked and supplemented by special searches after each hay and small grain crop had been removed. When possible, mowers were followed to obtain data on destruction of nests and injury to female pheasants. In order to avoid confusing the promiscuously-dropped single eggs with actual nesting attempts, the writer considered for nesting records only groups of at least two eggs.

The intensive method used sacrifices observations on large numbers of nests, but permits correlation of the data with those on cover composition and land-use of the area in a fashion scarcely possible in extensive researches. An earlier example of intensive investigation of pheasant nesting is English's (1933) work in Michigan. Hamerstrom (1935) and Leedy (1938) searched extensively for nests, while Randall (1939) confining his investigation to a circumscribed area, combined data from it with those taken from scattered portions of two counties.

In the present study, nests were visited periodically, although the periods varied. Records were kept on dates, numbers, and possible causes of disappearance of eggs, locations of nests with respect to cover types and to fences and other margins, plants present, and other details of nest ecology.

Brood counts were made with facility from roadsides early in morning and late in evening. Estimates of the ages of wild chicks were based on observations on the growth of a few pen-raised young.

Nest Location

In Table 1 acreages of different cover types are shown, and data on nesting

[1] Journal Paper No. J-769 of the Iowa Agricultural Experiment Station, Ames, Iowa. Project 497. Iowa State College, Iowa Conservation Commission, and the United States Bureau of Biological Survey cooperating with the American Wildlife Institute.

densities and nesting success are summarized.

For practical analysis, only 918 acres, or 60.4 per cent of the 1,520-acre plot, were considered potential nesting cover, and only data representing these acres are included in the table. The 602 acres excluded consisted of cornfields, farm groves, roads, and tracts in miscellaneous truck crops.

TABLE 1

ACREAGES, NESTING DENSITIES, AND NESTING SUCCESS

Cover Type	*Number of acres*	*Number of nests*	*Percentage of all nests*	*Acres per nest*	*Number of nests successful*	*Number of nests unsuccessful*	*Percentage of nests successful*	*Acres per successful nest*
I. Fence rows and road ditches	29.8	25	34.7	1.2	7	18	24.0	4.4
A. Fence rows	10.3	18	25.0	0.6	4	14	22.2	—
B. Road ditches	19.5	7	9.7	3.3	3	4	42.9	—
II. Hayfields	165.2	22	30.6	7.5	7	15	31.8	23.6
A. Wild hay	76.0	7	9.7	10.9	1	6	14.3	—
B. Alfalfa	41.3	6	8.3	6.9	1	5	16.7	—
C. Canary grass	41.9	9	12.5	4.6	5	4	55.5	—
D. Timothy	3.6	0	—	—	—	—	—	—
E. Red clover	2.4	0	—	—	—	—	—	—
III. Small grains	468.0	14	19.5	33.4	12	2	85.7	39.0
A. Oats	430.8	12	16.6	35.9	10	2	71.5	—
B. Barley	37.2	2	2.8	18.6	2	0	100.0	—
IV. Pastures	188.7	4	5.5	47.2	0	4	0.0	—
A. Bluegrass	130.8	2	2.8	65.4	0	2	0.0	—
B. Native grass	22.5	1	1.4	22.5	0	1	0.0	—
C. Sweet clover	15.4	1	1.4	15.4	0	1	0.0	—
D. Brome grass	20.0	0	—	—	—	—	—	—
V. Waste and idle land	66.3	5	6.9	13.3	1	4	20.0	66.3
A. Waste-sloughs	14.0	4	5.5	3.5	0	4	0.0	—
B. Idle (tillable)	52.3	1	1.4	52.3	1	0	100.0	—
VI. Miscellaneous in early cover later removed	(56.2)	2	2.8	28.1	0	2	0.0	—
Totals	918.0	72	—	—	27	45	—	—

The fence row-road ditch, hayfield, and small grain cover types were the most important, harboring 84.8 per cent of the nests.

The highest nesting density was in fence rows (a nest to 0.6 acres). These cover strips totaled only 10.3 acres—a little less than one per cent of the study area—but they contained 25 per cent of the nests. Many of these nests were early, and were begun when a high proportion of ground vegetated at the time was in fence rows. Similar concentrations of nests in fence rows have not in general been reported by other observers. For example, of 136 nests investigated by English (1933) in 1932 only 9.4 per cent were in these strips.

Although the birds were much attracted to fence row cover they had comparatively little nesting success there (22.2 per cent)—a result probably attributable to the use of fence strips as travel lanes by predators, as suggested by English (1933) and Hamerstrom (1935).

Hayfields contained nearly a third of the nests (30.6 per cent); the density

was much lower than in fence rows (a nest to 7.5 acres), but the percentage of success (31.8) was much higher.

Nests in alfalfa and in reed canary grass (*Phalaris arundinacea*) presented an interesting contrast, as follows:

	Alfalfa	*Canary Grass*
Acres	41.3	41.9
Number of nests	6	9
Nests successful	1	5

The difference in success in these two two types of hay was chiefly a result of the time of mowing. The "peak" hatch occurred in the period June 15–19, hence the mowing of alfalfa fields on June 8, 12, and 15 destroyed some of the nests, whereas the mowing of canary grass on June 24 and 26 and July 6, coming after most of the nests were empty, did little harm.

Small grains sheltered the greatest number of successful nests (12) of any of the cover types. The density of nests was low (one to 33.4 acres), doubtless on account of the late growth of this cover. The high percentage of success (85.7) was due to the later harvest and the high setting of the cutting bars. Two nests in oats were successful although they were cut over, but in hayfields no nests were successful after having been exposed by mowing. In northwest Iowa, Hamerstrom (1935) found few nests in small grain, but a high proportion of them was successful (47.1 per cent in small grains; 23.1 per cent in all cover).

In connection with their finding that many pheasant hens attempt renesting until they are successful in bringing off broods, Errington and Hamerstrom (1937) stated that manipulation of nesting cover in good pheasant range seems to have the greatest possibilities if stress is laid upon increasing the extent rather than the quality of nesting grounds. On the Winnebago Experimental Area, compliance with the AAA program has resulted in some augmentation of nesting cover by increasing the acreage in oats at the expense of that in corn. In general, however, intensive farming on the costly land of this area precludes increase of nesting cover to any great degree. Manipulation to raise the quality, on the other hand, may combine improvement of forage crops with lessened mortality among nesting females, even if there is little reproductive gain in the saving of nests. Under conditions on the Winnebago Area, canary grass has proved to be an improvement over native hays on peat land, and at the same time it affords good nesting cover for pheasants.

This investigation again corroborated Wight's (1930) statement that nesting material is a relatively unimportant factor for pheasants, as apparently there is always sufficient material in almost any cover. A wide variety of plant species was used in the nests. Trash from the preceding year's growth was often utilized, even late in summer. This tendency is illustrated by the use of fragments of old corn plants as linings of the nests in small grains.

Thirty-five of the 72 nests were located in fields with a minimum dimension greater than 200 feet, and these nests were arbitrarily designated as "field nests." The locations of field nests with respect to the nearest vegetation type-lines are tabulated below:

Percentage of 35 field nests	*Distance to nearest vegetation type-line*
40 per cent	less than 50 ft.
57 per cent	less than 100 ft.

The remaining 37 nests were in narrow strips of cover such as fence rows, road-ditches, or narrow extensions of fields, and all of them might well be considered peripheral in location. Wight (1930), English (1933), and Hamerstrom (1935) found evidences of a tendency for pheasants to place their nests at least proportionally near edges, but Leopold (1936) and Leedy (1938) found no such indications. However, Leopold (1936) suggested that crowding of nests might force the birds to accept non-peripheral locations, and Randall (1939) found more nests away from peripheries as nesting density increased. Since the density of nests recorded here was low as compared with Leopold's (1936) figures of one to two nests an acre in alfalfa, the connection between peripheral location and low density seems reasonable.

DESTRUCTION OF NESTS

The causes of failure of the 45 unsuccessful nests are recorded in Table 2.

Man was the most important single agent concerned in nesting failures, producing the loss directly or indirectly of 20 of the 45 unsuccessful nests (items I-B, I-E, II-F, and III, Table 2). In this connection, it may be recalled also that in some cases the differences in percentage of success in various cover types were traceable to man's agricultural activities.

Predation accounted for 40 per cent of the losses of nests but was distributed among several predatory species, probably no one of which exerted any particularly noticeable effect.

Seven of the nine nests tabulated in item III, Table 2, were destroyed during mowing of hay. In three cases the female was seriously injured; in the other six, only the nest was destroyed.

TABLE 2
CAUSES OF FAILURE OF NESTS

Cause of failure	*Number of nests*	*Percentage of total number unsuccessful*	*Number of eggs involved*
I. Desertion due to:			
A. Dump nests	1	—	21
B. Observer	5	—	51
C. Unknown causes	5	—	38
D. Disturbance by grazing animal	1	—	8
E. Disturbance by farmers	5	—	39
Totals	17	37.8	157
II. Predation by:			
A. Ground squirrel	2	—	24
B. Skunk	2	—	19
C. Mink	1	—	18
D. Weasel or mink	1	—	3
E. Crow	2	—	13
F. Man	1	—	12
G. Unknown carnivore	4	—	32
H. Unknown animal	5		27
Totals	18	40.0	148
III. Physical injury to hen or nest by farm machinery	9	20.0	85
IV. Flooding	1	2.2	14
Totals	45	100.0	404

PRODUCTION

Twenty-seven (37.5 per cent) of the 72 nests were at least partially successful. Percentages of success given by other observers (English, 1933; Hamerstrom, 1935; Leedy, 1938; Randall, 1939) are lower; the difference may result from the writer's exclusion of data for single eggs.

The average clutch size in the 27 successfully incubated nests was 10.4, and the average hatch was 8.7, indicating a loss of 1.7 eggs to each successful nest through infertility and delayed or imperfect hatching. In Table 3 are itemized the fates of eggs showing the extent of these losses.

TABLE 3

FATES OF EGGS

Item	*Number of eggs*	*Per cent of total*
I. Eggs in unincubated nests	404	50
II. Eggs in incubated nests	403	50
A. Eggs in unsuccessful nests	124	15.3
B. Eggs in successful nests	279	34.7
1. Eggs hatched	236	29.3
2. Infertile	18	2.2
3. Delayed or imperfectly hatched	17	2.2
4. Failed to hatch, reasons undetermined	8	1.0

Two of the eight eggs included in item II-B-4, Table 3, were found infested with ants, *Lasius niger neoniger*,[2] but since the eggs were in separate nests and as no other eggs in either nest were similarly infested, it seems probable that chicks died in pipping and that the ants arrived following their death.

The fertility of eggs was somewhat lower than that reported by Randall (1939) despite the fact that he found a sex ratio of about six females to one male, whereas the ratio was one male to 2.4 females on the Winnebago Area.

Counts showed a gradual decrease in size of broods with age (Table 4); the exception as to broods eight weeks of age or more may result from the assembling of different broods, a source of error mentioned by Errington and Hamerstrom (1937). After the chicks have attained an age of eight weeks or more, the heaviest losses have probably already been sustained.

TABLE 4

RELATION OF AGE TO SIZE OF BROODS

Age of young	*Number of broods counted*	*Mean number of chicks per brood*
1–3 weeks	3	8.3
4–5 weeks	15	7.3
6–7 weeks	28	6.1
8 weeks and more	25	6.9

The major causes of juvenile mortality are not known. A few chicks were mashed by hens before leaving the nests, a few were run over by automobiles, and a few were killed by farm dogs. Four marsh hawks (*Circus hudsonius*) hunted over parts of the area and since these birds were found to prey rather heavily on young pheasants in northwest Iowa (Errington and Breckenridge, 1936), some of the losses may be attributable to them.

On the 1,520-acre plot, 27 nests were known to have been partially successful and 235 chicks were brought off from them. Assuming an average brood-size of six chicks, we have $27 \times 6 = 162$ chicks reaching the stage of organization in loose flocks. Assuming further that $\frac{3}{4}$ of

[2] Identified by William Buren.

the nests were found[3] we may multiply 162 by $\frac{4}{3}$, with a product of 216 (young produced on 1,520 acres). Converting this figure, we have approximately 90 young produced to a section (640 acres).

Enumeration in the spring, by a modified spot-census method, indicated a breeding population of about 50 pheasants to a section. The total population in the fall should, then, have been about 50+90 or 140 pheasants to a section, and the increase about 180 per cent. Actual fall census work performed by the roadside method of Bennett and Hendrickson (1938) and by flushing counts made during the hunting season, indicated a population of 130–150 pheasants to a section.

SUMMARY

(1) A plot of 1,520 acres was chosen for intensive pheasant nest research on the Winnebago Experimental Area in north-central Iowa. Seventy-two nests were found on the tract after repeated systematic searches.

(2) A table showing acreages in various types of cover, densities of nests in them, and percentages of success of the nests, is presented. 34.7 per cent of the nests were found in the limited acreages in road-ditches and fence rows, but here the percentage of success was low. The density of nests in fields of small grain was low but the percentage of success was high. Density and percentage of success were intermediate in hayfields. Canary grass appeared to offer more efficient nesting cover than alfalfa. The fence row, road ditch, hay field and small grain types contained 84.8 per cent of the nests found.

(3) Tables are included showing fates of eggs and agents in the destruction of nests. Twenty-seven of the 72 nests were successful. Predation accounted for the loss of 40 per cent of the unsuccessful nests, but the damage was distributed among several predatory species. Man was the most important single agent in causing losses of nests.

(4) The mean clutch size for successful nests was 10.4, the mean hatch 8.7, and the probable mean brood size for older broods about six. It was estimated that 90 young were produced by 50 adult pheasants per section.

[3] Checks in hayfields showed that approximately half of the nests had been found *before* mowing. However, more attention was given to types of cover that could not be checked in an attempt to balance data in checkable and noncheckable cover. Further it is of course true that the checks themselves raised the percentage of nests found in these fields to a very high point.

LITERATURE CITED

BENNETT, LOGAN J., and GEORGE O. HENDRICKSON.
1938. Censusing the ring-neck pheasant in Iowa. Trans. Third North American Wildlife Conf. 3:719–723.

ENGLISH, P. F.
1933. Causes of pheasant mortality in Michigan. Unpub. Ph.D. thesis University of Michigan Library, Ann Arbor, Michigan.

ERRINGTON, PAUL L., and W. J. BRECKENRIDGE.
1936. Food habits of marsh hawks in the glaciated prairie region of north-central United States. American Midland Naturalist, 17: 831–848.

ERRINGTON, PAUL L., and F. N. HAMERSTROM, JR.
1937. The evaluation of nesting

losses and juvenile mortality of the ring-necked pheasant. JOURN. WILDLIFE MANAGEMENT, 1: 3–20.

GREEN, WILLIAM E.
1938. The food and cover relationship in the winter survival of the ring-necked pheasant, *Phasianus colchicus torquatus* Gmelin, in northern Iowa, Iowa State Coll. Journ. Sci., 12: 285–315.

GREEN, WILLIAM E., and WATSON E. BEED.
1936. Iowa quail and pheasants in winter. American Wildlife, 25: 83–84, 90–92.

HAMERSTROM, F. N., JR.
1936. A study of the nesting habits of the ring-necked pheasant in northwest Iowa. Iowa State Coll. Journ. Sci., 10: 173–203.

LEEDY, DANIEL L.
1938. Pheasant nesting study, Wood County, Ohio—1937. Ohio Wildlife Research Station (Ohio State Univ.) Release 82. 9 pp. mimeographed.

LEOPOLD, ALDO.
1936. 1936 pheasant nesting study. Wilson Bul., 49: 91–95.

RANDALL, PIERCE E.
1939. Nesting habits and causes of nest mortality of the ring-neck pheasant. Pennsylvania Game News, 10: 6–7, 30.

WIGHT, H. M.
1930. Pheasant management studies in Michigan. Trans. 17th American Game Conf., American Game Association, 17: 220–231.

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A TECHNIQUE FOR REMOVING LEAD FROM THE GIZZARDS OF LIVING WATERFOWL[1]

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The death by lead poisoning of many waterfowl has been reported from several parts of the country by various authors, particularly Wetmore (1919) and Schillinger and Cottam (1937), and more recently there have been numerous reports of birds found sick and unable to fly more than a short distance. Many such disabled birds have been found to be victims of lead poisoning, and these cases have suggested to the writer the possibility of a technique for removing the lead shot from such birds in order to improve their chances for recovery. An apparatus which could remove the contents from the gizzard of a living duck without injuring it might prove useful for other purposes as well, but treatment of lead-poisoned birds was the objective of the efforts here described.

By means of the use of an aspirator (Figure 1) both the proventriculus and gizzard of ducks affected by lead poisoning have had their contents removed with no apparent injury to the bird in most cases. Exceptions were those individuals exhibiting last stages of paralysis with the accompanying rapid heart beat. These birds apparently died from the shock induced by excitement during the handling and aspirating. In some cases specimens of this nature have been successfully pumped, but life seems merely to be prolonged rather than insured. Failure to recover was probably due to the amount of lead already absorbed by the system.

A short description of the physiological effects of lead poisoning is necessary as a basis for showing the conditions under which much of the work of the aspirator must be carried on. These may be stated as follows:

a) Various stages of paralysis of wings, legs, and neck are dependent on the quantity of lead absorbed and the length of time affected.

b) Feces are green and watery and are often expelled as the result of excitement or exertion.

c) Partial paralysis of the alimentary tract inhibits normal peristalsis with resultant clogging of the gizzard and proventriculus. At this stage the grinding action of the gizzard is weakened and the bird is unable to digest hard foods. Thus, many birds, although crammed with food, may exhibit extreme emaciation.

Anatomy of waterfowl lends itself well to the insertion of a pump of the type to be discussed, since there is a straight-line succession of organs as follows: oral opening, pharynx, esophagus, proventriculus, and gizzard. In addition to the straight-line arrangement the organs are distensible making it possible to insert a tube one-half inch in diameter. Larger diameters are apt to cause suffocation because of the close proximity of the esophagus and trachea and may even rupture the esophagus or the sphincter at the gizzard entrance. However, the larger the diameter of the

[1] Paper No. 1820 Scientific Journal Series. Minnesota Agricultural Experiment Station, St. Paul.

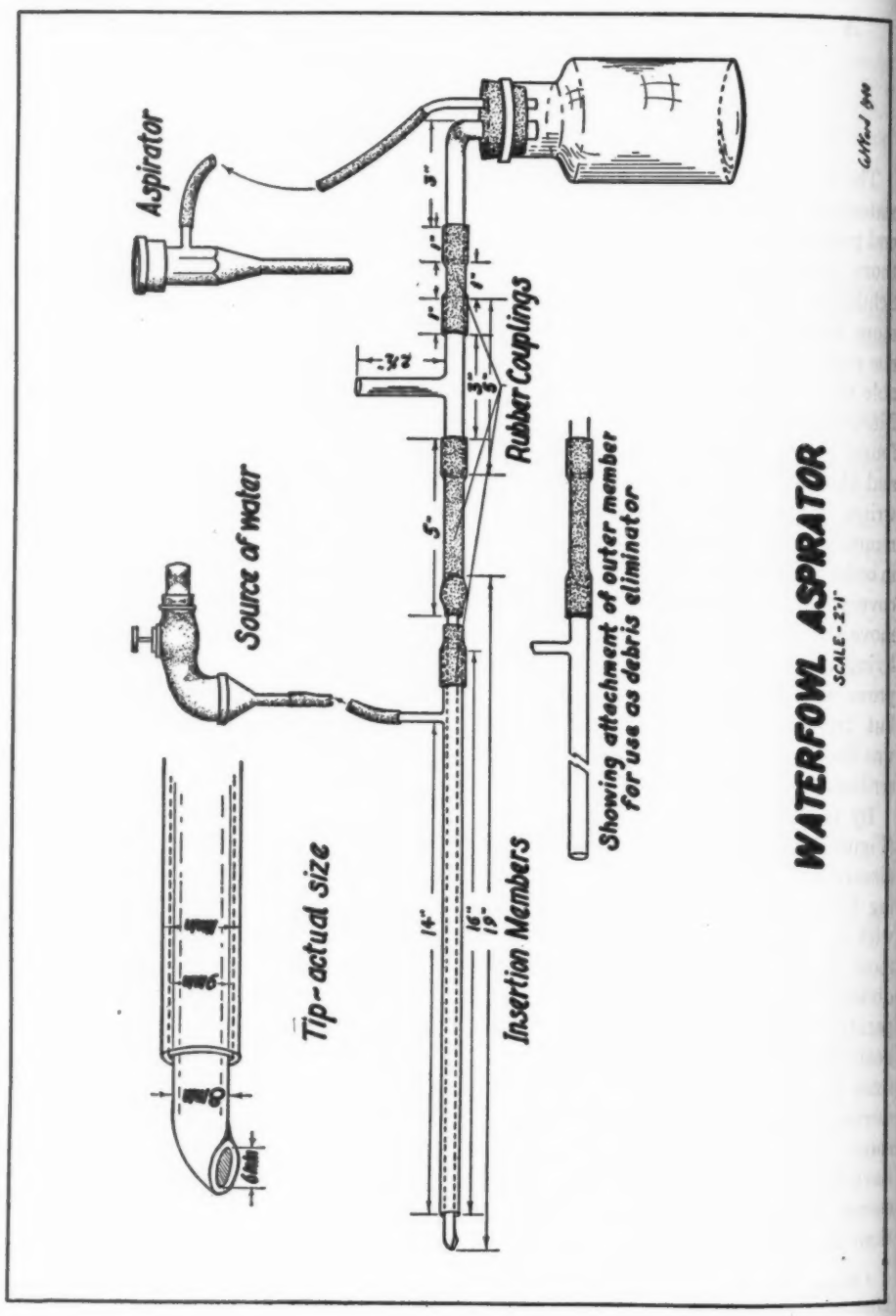
Aspirator
Source of water
Rubber Couplings
Tip - actual size
Insertion Members
Showing attachment of outer member for use as debris eliminator
WATERFOWL ASPIRATOR
SCALE - 2:1

Figure 1

Figure 1

Jour

Mallard being treated with stomach pump.

UNIV. OF MICH.

tube that can be used safely, the greater the ease in removing larger materials such as corn, grain, and certain particles of grit. These materials, when drawn into a smaller tube may jam and necessitate a waste of time in their removal. Nevertheless, if the birds in question have not been feeding on these larger food items a smaller-sized tube is preferable, eliminating some discomfort to the birds and increasing the proficiency of the vacuum action in dislodging and evacuating the shot from the gizzard.

A transparent tube of one of the various plastics is probably preferable to one of pyrex, because the danger of chipping the tip of the insertion tube would thus be eliminated, but so far pyrex is the only material that has been used.

As the opening to the gizzard is antero-superior it is necessary to place the bird on its back (Plate 15) while being pumped to allow the flushing action to settle the shot at the opening and along the dorsal groove (ventral as the bird lies on its back) where it can be sucked out more readily. A combination of the two sizes is preferable, the larger to be used first as a debris eliminator and the smaller to do the actual small seed and shot removal. With these factors in mind the following description of the aspirator may be understood more easily.

A water aspirator of the type shown in the diagram is connected to a vacuum reservoir consisting of a pint mason jar or similar receptacle fitted with a rubber stopper bored to receive two L tubes, one of which should approximate 11 mm. in diameter and the other a diameter corresponding to the pressure tubing connection of the aspirator. To the 11 mm. elbow a T tube is connected by a rubber coupling. The opposite end of the T is connected to the inner member of the insertion tube by a five-inch rubber coupling. The greater length of this latter tubing is to allow freedom in manipulation of the insertion tubes. The outer member of the insertion tube is fitted with a sidearm to receive a rubber hose for a regulated water supply. This supply acts as a flushing and transporting agent and should preferably consist of luke-warm water. Water flows between the inner and outer members of the insertion unit and is prevented from backing up by a tight-fitting section of rubber tubing fitted over the outer member nearest the vacuum reservoir and snugly encircling the wall of the inner member at this point.

As stated previously it may be necessary to use a larger (approx. $\frac{1}{2}''$) tube as a debris eliminator. Such a tube might be used alone, that is, without the inner member previously described. In this case it would act intermittently as source of water and vacuum by manipulation of pinch clamps on the rubber tubing leading to the water supply, and that to the vacuum line. These clamps must be released alternately; viz.: water —vacuum—water—vacuum, thus utilizing the vacuum to remove materials loosened and made transportable by the injection of the water. The outer member of the two-member unit can be used in lieu of the additional larger tube simply by removing the inner member and connecting the five-inch rubber coupling directly to the outer tubing; manipulation following the above description.

The technique of operating the aspirator, although simple, depends for

much of its success on the manual skill of the operator. Utmost care must be exercised for successful manipulation.

When the apparatus has been set up the aspirator is adjusted to pull a strong current of water through the inner tube when the T-tube is stoppered by placing the index finger over the opening. This vacuum need not be exact for the T-tube acts as a safety valve and should not be stoppered when actual pumping is taking place. Occasional touches over the mouth of the tube may be desirable to help draw through heavier particles that tend to remain in the vacuum tube. *Only enough vacuum to draw out gizzard contents slowly is necessary.* Higher vacuums may slough off the inner wall of the gizzard which tends to become disintegrated in lead-poisoned birds.

The volume of flushing water is exceedingly important for under no conditions should it be more than can be removed continuously by the aspirator. A mere trickle from the end of the tube held in a horizontal position seems sufficient. This water acts not only as a loosening and flushing agent but also as the transporting medium of the proventriculus and gizzard contents to the reservoir. With *care* this pressure may be used to expand the convolutions of the gizzard slightly, setting free the entrapped particles to drop to the floor (dorsal side) of the organ where they are more easily picked up by the suction tube.

Insertion of the tubes should begin after the vacuum and flushing water pressures have been regulated and should proceed slowly with greatest caution. The bird is placed on its back on a level with, or slightly above, the top of the reservoir and held firmly though not tightly. Birds suffering from lead poisoning tend to have rapid heart beat and undue pressure or roughness may cause death by shock.

As the tube is worked through the esophagus it must pass through the furculum or wishbone opening. This passage should not be forced but may be accomplished by slight exploratory movement of the tube. Once located, further insertion is easy until debris in the proventriculus or the gizzard sphincter is encountered. The former material must, of course, be removed before the gizzard can be reached and the sphincter forced by slight pressure. Once the gizzard has been penetrated (may be felt by placing the fingers over the gizzard at the posterior end of the sternum—an insertion of about fifteen inches in a mallard) the tip of the vacuum tube should be manipulated forward and backward with a slight twisting motion to dislodge any materials that might be concentrated there.

Several partial or complete withdrawals from the tract seem to accomplish the best results. Whether or not the bird flexes the gizzard walls voluntarily has not been determined but on repeated tests materials were often more readily obtained after such withdrawals. Too, they afford a period for the bird to breathe normally, reducing the chances of suffocation or drowning. Periodic emptyings of the reservoir may be necessary depending on the extent of the pumping required. Experience enables the operator to feel the degree of evacuation of the gizzard and to stop operations before overpumping has occurred.

After completion of the pumping the birds should be placed in moderately

heated pens and supplied abundantly with water, food and gravel. Mash or other soft foods are desirable because the paralysis of the gizzard musculature in lead-poisoned birds prevents proper utilization of hard foods.

The work so far has been confined to the mallard, black duck, and pintail although there is no doubt that one can get similar results with other birds if the proper size insertion tubes are used. The apparatus has been tested on more than twenty birds containing lead shot, including birds taken in nature and some fed shot experimentally. In the specimens investigated later by autopsy or x-ray, all shot were found to be removed. As many as 26 shot were removed from one poisoned bird sent to the laboratory. Preliminary results, limited by the number of ducks obtainable, cannot be taken as decisive; however, they have shown that a pump of this type can be inserted without injury to a living duck and also that the chance of survival is greater after the removal of the lead. No claims are made for the apparatus but the technique is being made available for use by those who may be interested.

Besides the simple removal of shot, other avenues of inquiry are opened up by the use of the aspirator, most important I believe to be that of food analysis. Food preference throughout different seasons of the year in migration or on the breeding or wintering areas may be determined by trapping and evacuating healthy birds. This evacuation may be carried on as a by-product of bird banding. It affords an excellent opportunity for creation of food preference collections.

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LITERATURE CITED

SHILLINGER, J. E., and CLARENCE C. COTTAM.
1937. The importance of lead poisoning in waterfowl. Trans. 2nd. N. A. Wildlife Conf., pp. 398–403.

WETMORE, ALEXANDER.
1919. Lead poisoning in waterfowl. U.S.D.A. Bul. 793, pp. 1–12.

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BROOMSEDGE AS A FOOD FOR WILDLIFE

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Among wildlife managers it has generally been assumed that the ubiquitous broomsedge of the South is of relatively little value to wildlife. This belief, based largely on observation, has in fact, been strengthened by a certain amount of data. Thus while Handley reported that seeds of this plant occurred in 214 of the 1,659 bob-white stomachs examined in the Cooperative Quail Investigation, he expressed the belief that probably most of the seeds were taken accidentally, stuck to the woolly pods of beggar-weed. Stoddard has also pointed out that while small areas of open broomsedge are greatly favored by bob-white for nesting, feeding, and roosting and are highly desirable, the reverse is true of large tracts of dense broomsedge.

Records from the Food Habits Section of the Biological Survey also tend to show that little value may be assigned to broomsedge. Out of about 2,000 bob-white stomachs examined, 70 contained broomsedge—usually present as a single seed. Twenty out of 350 turkey stomachs contained a seed or two, and one ruffed grouse stomach in about 3,000 studied contained a broomsedge seed. In addition there is one record each for the junco, chipping sparrow, and field sparrow. Finally, Davison (unpublished) and his coworkers in the Soil Conservation Service examined 2,933 bob-white crops taken in the fall and winter in 7 southeastern States and found that only a few contained seeds of broomsedge in negligible amounts.

In view of this negative evidence it seems worthwhile to record what can only be classed as extensive utilization of broomsedge seeds for food by small birds in Mississippi during the past severe winter. Specifically, on January 23, 1940, the day following an abnormally heavy snowfall for Mississippi, for approximately a hundred miles south of Jackson along U. S. Highway 51, a number of species of small birds, notably juncos and song sparrows, were observed to be feeding on broomsedge—the only apparent food available above the 12-inch snow.

Wherever clumps of broomsedge were to be found near the road, groups of as many as 10 or 15 birds were busily engaged in stripping the stalks of their seeds. They would fly into the air, perch on or near the tip of the grass culm, bend it to the snow surface by their weight, then extract the seeds and eat them. The accompanying photograph (Plate 16) shows juncos engaged in this activity.

There is no way of estimating the thousands of birds that must have tried to sustain themselves on the food offered by broomsedge seeds. But there is little doubt that the several hundred birds observed feeding would have been in even worse straits than we saw them had it not been for *Andropogon virginicus*. This assumes that the birds could live for a while on an unusual diet, but hard-pressed explorers have existed on shoe leather until better food could be obtained, and it is reasonable to conclude that the birds observed were in an analogous situation.

Juncos feeding on broomsedge (*Andropogon virginicus*) under severe winter conditions in Mississippi.

This observation can scarcely be interpreted to mean that broomsedge should be planted or used in wildlife management. But it does indicate that what are apparently worthless plants may, in times of great stress, bridge the gap between starvation and survival.

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A PRELIMINARY REPORT ON THE STUDY OF WHITE-TAILED DEER IN THE EDWARDS PLATEAU OF TEXAS

Earl Sanders[1]

This report deals with weights, and body and antler measurements of white-tailed buck deer taken during the 1938 hunting season in Gillespie, Kerr, Llano, and Mason Counties in the Edwards Plateau of Texas. It also includes data from the shooting preserve record books for 1938 in that area. The deer population in these counties is not equaled by that of any other four counties in the State.

Previous to this research the writer heard many comments by sportsmen, land owners, and others maintaining that the size of deer and their antlers vary from county to county. They also claimed that both body and antler size are becoming smaller. The purpose of this investigation was to find out if these conditions exist and if they do, to determine as many as possible of their causes.

Description of the Edwards Plateau

The Edwards Plateau is located in West Central Texas. It is of an irregular, rectangular shape and contains approximately 24,000 square miles. It lies between 29° and 32° N. Latitude and 98° and 101° W. Longitude. Its southern and eastern boundaries rise abruptly from the coastal plain to an elevation of 1,500 to 1,800 feet. It slopes gently to the northwest with a gradually increasing elevation to the Staked Plains of northwest central Texas. The general topography is rolling to rough, cut by many canyons, small streams, and gullies.

The trees of this region consist principally of mixtures of: live oak (*Quercus virginiana*), shin oak (*Quercus undulata*), Spanish oak (*Quercus falcata*), post oak (*Quercus stellata*), white oak (*Quercus alba*), black jack (*Quercus marilandica*), cedars (*Juniperus* spp.), mesquite (*Prosopis glandulosa*), hackberry (*Celtis*), and cottonwood (*Populus palmeri*), with some cypress (*Taxodium distichum*), pecan (*Carya buckleyi*), walnut (*Juglans*), and elm (*Ulmus*), along the streams. These provide browse for the deer while the mast crop is a valuable addition to their autumn and winter food. The black persimmon (*Diospyros texana*) occurs in small amounts and its ripe fruit appears to be considered a delicacy by the deer.

Deer management in Texas presents special problems. In the majority of the states, deer management practices are planned for public lands; but in Texas while the deer are considered to be the property of the state they must be managed on land that is privately owned. The best management of the deer in a fair manner for all interests here requires the cooperation of land owners, sportsmen, scientists, and the Texas Game, Fish, and Oyster Commission.

Specific data about the four counties selected for this research are presented

[1] Employed by the Texas Game, Fish, and Oyster Commission from July 1, 1938 to October 31, 1939.

TABLE 1

AREA, POPULATION, AND ACRES PER ANIMAL UNIT OF DOMESTIC STOCK[1]

County	*Area in acres*	*Human population*	*Human population per square mile*	*Number of acres per animal unit*
Kerr	729,880	10,151	8.9	10.05
Llano	621,440	5,538	5.7	10.06
Gillespie	709,760	11,020	9.9	7.18
Mason	620,160	5,511	5.9	8.47

[1] Data compiled from the 1935 Department of Agriculture Census.

in Table 1. These counties are adjoining and are located in the east central part of the Edwards Plateau.

EQUIPMENT AND PERSONNEL FOR THE DEER WEIGHING AND MEASURING PROGRAM

Since the deer were taken on widely scattered ranches, it was not possible, with the personnel available, to maintain checking stations on highways. The most economical plan was to work at the cold storage plant in each of the counties. A wildlife technician and one assistant to record data were stationed at each of these plants. The scales that were used had passed inspection by the Bureau of Standards for Texas. The measurements were made with a flexible steel tape graduated in millimeters. The zygomatic breadths and head lengths were taken with calipers.

DEER WEIGHTS AND MEASUREMENTS

Weight and antler point records were procured for 825 deer and measurements were made of 170. Weights of 83 other deer taken on one ranch in Mason County and weighed by a reliable ranchman also are included in the tabulation. For these records a point was arbitrarily defined as any antler projection one inch or more in length, and the basal snag or prong was counted. The ages of the deer were not determined because sufficient research on skulls in this locality had not been done. About 70% of the deer kill was made during the first week of the hunting season and most of the records were obtained during that time. The percentages of the deer kill investigated are shown in Table 2.

TABLE 2

PERCENTAGE OF THE DEER KILL WEIGHED

County	*Deer weighed*	*Deer reported killed*	*Percentage of total kill weighed*
Kerr	156	987	15.8
Llano	209	1,045	20.0
Gillespie	388	1,601	24.2
Mason	72	1,984	3.6
One Mason County Ranch	83		4.2
Totals	908	5,617	16.16

The numbers of deer in each weight class and the average weight of each class for each county are presented in Table 3. It also shows the average weight of all the handled deer for each county. The largest number of deer in a weight class for each county, not including the 83 deer from the one Mason County ranch, is that for the 61–70 pound class and the second largest number is that for the 71–80 pound division. The inclusion of the 83 deer from the one Mason County ranch causes an interchange of the weight classes contain-

TABLE 3

NUMBER AND AVERAGE WEIGHT OF DEER GROUPED IN WEIGHT CLASSES BY COUNTIES

Weight class[1] *(in pounds)*	*Kerr*	*Llano*	*Gillespie*	*Mason*	*Mason County Ranch*	*Total numbers and average weights*
41– 50	5 44.74	4 44.75	13 47.23	4 48.75	1 50.00	27 47.15
51– 60	10 55.50	28 56.64	65 56.83	12 53.92	14 56.07	129 56.77
61– 70	39 66.08	77 65.60	110 65.39	22 64.86	27 65.81	275 65.18
71– 80	35 75.77	47 75.17	109 74.49	21 74.81	29 74.48	241 74.85
81– 90	27 84.70	25 85.24	40 84.85	11 84.18	11 85.18	114 84.88
91–100	23 95.43	14 95.42	33 95.15	1 99.00	1 97.00	82 95.37
101–110	11 107.00	8 104.50	13 104.77	1 101.00		33 105.27
111–120	4 115.50	4 116.50	3 116.00			11 116.00
121–130	2 125.00	2 125.50	2 125.50			6 125.33
Number of deer	156	209	388	72	83	908
Individual county mean	79.56	73.60	72.46	69.52		73.50
Standard error	±1.34	±1.06	±0.75	±0.89		
Standard deviation	16.7	15.4	14.7	11.1		

[1] Dressed weight in pounds (all viscera except kidneys removed).

ing the largest and second largest number of deer for this county. The third largest number for Kerr County is for the 81–90 pound weight class, while for Llano, Gillespie, and Mason Counties the third largest number represents the 51-60 pound deer. The percentages of the animals included in these three weight classes for each county and the ranch were: Kerr 65 per cent; Llano 73; Gillespie 73; Mason 76; and the ranch 83. The remaining percentages are distributed in varying amounts among the six other weight classes. The table shows a difference of 10.04 pounds between the highest average weight of 79.56 pounds for Kerr County and the lowest average weight of 69.52 pounds for Mason County. These data support the claim that the deer vary in weight from county to county.

ANALYSIS OF VARIANCE

	Degrees of freedom	*Sum of squares*	*Mean square*
Between counties	3	74.28	24.76
Within counties	904	1947.84	2.15

It is clear from statistical treatment of the data in Table 3 that Kerr County deer are significantly heavier than any of the others. The difference between the Llano and Gillespie County animals is not conclusively established. The Mason County population differs from the others both in mean and in standard deviation.

The data summarized in Table 4 show that the largest number of deer for each county as to antler point class is in the 4×4 category. The second largest number for Kerr and Llano Counties occurs in the 3×3 antler point class, while in Gillespie County it is in the 3×4 division, and in Mason County the 3×3 and 3×4 classes tie for second place. The third largest number is in the 3×4 category for Kerr, in the 1×2 class in Llano, and in the 2×2 class in Gillespie Counties. The percentages of deer included in these leading three antler point classes for each county are for: Kerr 64, Llano 54, Gillespie 55, and Mason 57. The remaining percentages of deer are distributed in varying amounts among the ten other antler point classes. The data show that the number of antler points varies from county to county. The data, with only two exceptions, also show that the number of antler points increases with the average weight for groups of ten per cent or more of the deer in the same antler point class.

The compilation of study material

TABLE 4

NUMBER AND AVERAGE WEIGHT OF DEER GROUPED IN ANTLER POINT CLASSES BY COUNTIES

Antler point class	*Kerr*	*Llano*	*Gillespie*	*Mason*	*Total*
1×1		2 66.50	11 63.27		13 63.77
1×2	7 60.71	26 64.92	21 59.43	9 58.22	63 61.66
2×2	13 61.77	24 66.04	52 62.29	8 59.62	97 63.27
2×3	2 70.00	22 67.04	44 69.32	10 68.10	78 68.53
3×3	27 71.04	35 72.92	51 70.90	12 67.92	125 71.12
3×4	16 70.06	24 74.66	56 74.48	12 72.56	108 73.64
4×4	57 84.28	52 78.15	104 77.72	17 78.29	230 79.49
4×5	12 86.50	6 100.00	13 85.38	1 67.00	32 87.66
5×5	12 99.92	4 97.50	11 90.64		27 95.77
5×6	5 93.60	3 91.00	2 74.50		10 89.00
6×6		1 117.00	1 103.00		2 110.00
6×7	1 108.00				1 108.00
Odd	4 91.00	10 71.40	22 73.77	3 67.33	39 74.42
Number of deer	156	209	388	72	825
Average weight	79.56	73.60	72.46	68.99	73.77
Average number antler points per deer	7.27	6.26	6.27	5.88	6.42

presented in Table 5 for weight classes in which there are ten or more deer, shows that the circumference of each antler burr, of each antler one inch above the burr, and of the antler midway between the basal snag and the first branch increases with increase in weight. The length of each antler, the antler spread, zygomatic breadth, and length of hind foot also increase with weight and the head and tail lengths show an increase in most of the weight classes. There seems to be no definite relationship, however, between increase in weight and distance between burrs. Among all the measurements, the closest correlation seems to exist between increase in weight, zygomatic breadth, and length of hind foot.

TABLE 5

SUMMARY OF AVERAGES OF WEIGHTS AND MEASUREMENTS[1]

(Weights in pounds, measurements in millimeters)

Weight classes[2]	Average weight	Number of deer	Circumference of antler burr		Antler length		Circumference of antler 1" above burr		Circumference of antler midway between basal snag and first branch		Greatest antler spread	Distance between burrs	Head length top of nose to cranial crest	Zygomatic breadth	Tail length	Length left hind foot
			R.	L.	R.	L.	R.	L.	R.	L.						
41– 50	45.17	6	84	85	240	244	58	57	48	49	216	56	214	95	209	402
51– 60	56.58	12	84	87	226	234	58	60	49	49	225	56	242	100	208	415
61– 70	64.97	47	93	93	276	276	66	66	58	56	275	59	227	106	214	417
71– 80	75.00	31	104	104	314	314	75	75	64	63	299	58	235	110	220	422
81– 90	85.08	37	108	109	357	361	79	79	70	70	336	59	229	113	213	426
91–100	94.76	17	122	122	383	379	87	87	77	77	385	58	241	114	215	427
101–110	105.40	15	132	136	452	447	92	92	86	87	413	55	252	117	228	430
111–120	115.33	3	134	138	381	366	96	103	81	81	418	59	255	120	231	435
121–130	126.50	2	139	142	501	484	101	97	86	88	421	65	265	129	213	443
Average of all measurements	78.05	170	105	106	337	327	76	76	65	65	312	58	233	109	217	422

[1] Deer were not grouped by counties because of the small numbers in the categories.
[2] Dressed weight in pounds (all viscera except kidneys removed).

DATA COLLECTED FROM SHOOTING PRESERVE RECORDS

Each ranchman who leases hunting rights pays a $5.00 fee for a shooting preserve operator's license and receives a record book which he returns to the Texas Game, Fish, and Oyster Commission after the close of the hunting season. There are many ranchmen, however, who do not lease hunting privileges. Only invited guests hunt on these ranches and at present no State records are kept of the game killed.

The record book is provided with spaces for filling in the following data for each hunter: date of hunting, hunter's name, residence address, license number, days spent hunting, and number of each species of game killed.

The data in Table 6 were computed from the records of 392 shooting preserves. There were 39 other shooting preserves containing 41,618 acres that reported no deer killed. The county that had the smallest number of deer killed on its shooting preserves had the largest number of acres per deer killed on its preserves. As the number of deer killed on preserves in different counties increases the number of acres per deer

TABLE 6

SUMMARY OF RECORDS OF SHOOTING PRESERVES REPORTING DEER KILLED

County	*Number of shooting preserves*	*Number of of deer killed*	*Number of acres in shooting preserves*	*Number of acres per deer killed*
Kerr	111	987	333,694	338
Llano	54	1,045	179,401	172
Gillespie	160	1,601	242,534	151
Mason	67	1,984	208,468	105
Totals	392	5,617	964,097	172

killed on preserves decreases but this decrease is not uniform.

As shown in Table 7 there is a negative correlation between the average dressed weight of deer and the number of deer killed on shooting preserves. There is a positive correlation between the average dressed weight of deer, the number of acres per deer killed on shooting preserves, and the number of acres per deer killed in each county, using its total area as a unit. The county that had the highest average dressed weight of deer had the largest number of acres per deer killed on shooting preserves. The county having the lowest average dressed weight of deer had the smallest number of acres per deer killed on its shooting preserves. As the number of deer killed on shooting preserves in a county increases the average dressed weight and the number of acres per deer decreases. The table shows that the number of acres of grazing per domestic animal unit does not correlate so closely as the other data in the first four columns of the table but they indicate the importance of grazing pressure on a range that receives an average of only 27 inches of rainfall annually. A possible explanation for the smaller number of acres per animal unit in Gillespie County than in Mason may be the use of supplementary feed in the former. A very large percentage of farmers and ranchmen in Gillespie County raise large amounts of forage for their livestock, a practice much less common in Mason County.

The preceding data and those presented in Table 8 show very clearly the urgent need of adequate scientific management in these four counties and especially in Mason and Gillespie. There are at least 86 ranches containing 200,700 acres in these four counties

TABLE 7

SUMMARY OF DATA

County	*Average dressed weight of deer in pounds*[1]	*Number of deer killed on shooting preserves*[2]	*Number of acres per deer killed on shooting preserves*[3]	*Number of acres per deer killed using county as a unit*[3]	*Number of acres per domestic animal unit*[4]
Kerr	79.56	987	338	739	10.05
Llano	73.60	1,045	172	595	10.06
Gillespie	72.46	1,601	151	443	7.18
Mason	68.99	1,984	105	312	8.47

[1] Weights are from Table 4.
[2] Data from Table 6
[3] Compiled from Table 1.
[4] Data from Table 1.

TABLE 8

SUMMARY OF RECORDS OF SHOOTING PRESERVES ON WHICH THE DEER KILL WAS ONE OR MORE PER 100 ACRES AND CALCULATIONS OF THE NUMBER OF ACRES PER DEER FOR UNIT HERDS

County	*Shooting preserves*	*Deer killed*	*Acres in shooting preserves*	*Acres per deer killed*	*Acres per deer calculated for herd of 12 deer per buck killed*	*Acres per deer calculated for herd of 15 deer per buck killed*
Kerr	4	108	9,330	86	7.20	5.76
Llano	15	413	33,850	82	6.83	5.46
Gillespie	37	594	40,957	69	5.76	4.60
Mason	30	1,402	116,543	83	6.92	5.54
Totals	86	2,517	200,680			
Averages				79	6.58	5.27

on which the deer population is too high as shown by the fact that one buck was removed from each 79 acres. The high population indicated on the basis of a bagged buck representing 12-15 deer on the range suggests some very important problems affecting the welfare of the animals. That of first rank, perhaps, is the food supply. Before this can be evaluated, definite information is needed on what constitutes a unit herd in these counties. Is the present herd of correct age and sex composition? What is the carrying capacity of the range? To what extent are domestic animals and deer directly competing for forage?

A unit herd is that number of animals of both sexes and all ages which barely maintains its numbers from year to year replacing losses from all causes. Leopold (1933, pp. 188-190) in writing of mule deer in the Gila National Forest of New Mexico states that a herd of 24 deer is required to produce one shootable buck annually. The corresponding size of herd for these Texas counties is not known at present but judging from the available records the writer believes that a herd of from 12 to 15 may be necessary. If the smaller number is correct then each deer has about seven acres of range on the densely populated ranches in Mason county, but if the larger herd requirement of 15 is needed to produce a shootable buck, each deer would have only about five and one half acres of range on these ranches. Other records together with the fact that one buck was killed on each 79 acres of these 86 ranches lead

TABLE 9

COUNTY AVERAGE NUMBER OF ACRES OF RANGE PER HEAD FOR DIFFERENT KINDS OF DOMESTIC STOCK[1]

County	Acres per head				
	Cattle	Sheep	Goats	Horses and mules	Hogs
Kerr	56	5	6	235	382
Llano	16	34	27	218	37
Gillespie	26	4	7	101	113
Mason	18	6	9	179	72

[1] Data compiled from the 1935 Department of Agriculture Census.

the writer to conclude that there is an unbalanced sex composition of the deer herds, and possibly also an unbalanced age composition. The more the sex and age composition of the herd is out of balance the larger is the number of nonproductive animals in the herd. The nonproductive animals are does which are barren because of age or shortage of bucks. Dependent on their number these deer may decrease the average amount of range available for each deer even below that calculated in Table 8.

It should be borne in mind also that this dense deer population lives upon a range that is shared with domestic stock. Table 9 shows the number of acres of range available for each head of cattle, sheep, goats, hogs, and horses and mules. The sheep and more especially the goats are definite competitors with the deer for browse.

The presence of so many domestic animals and deer upon the same range presents some very serious grazing management problems for the ranchmen and the Texas Game, Fish, and Oyster Commission. The ranchmen control the increase of the different kinds of domestic stock by selling the surplus of both sexes and so limit the number of animals to whatever they think the range can carry safely. The Game, Fish, and Oyster Commission cannot so act because it does not have regulatory power to limit the number of deer on the range, to dispose of excess does, or to limit the kill. A buck law that limits the legal kill to two bucks per hunter has been in operation for many years. The logical solution of the excess doe problem in these congested areas is to have an open season on antlerless deer but at present there is no legal authority for such hunting. Unless some provision is made for decreasing the over-population on these ranches there is very grave danger that the deer will destroy their food supply and starve. This would be another example of mismanagement or lack of management similar to those of the Kaibab Forest in Northern Arizona, and other localities both east and west where the deer ate themselves out of "house and home."

SUMMARY

1. Weight and antler point records were made during the 1938 hunting season in Texas for 825 buck deer, and body and antler measurements were made for 170 of them. The weights of 83 other deer, all that were killed on one ranch in Mason County, also were included in the study data.

2. The total number of deer killed, and the ranch and acreage distribution for 431 ranches were obtained from shooting preserve record books for the 1938 hunting season.

3. The records of dressed weights, number of antler points, and antler and body measurements show the following:

a. The largest number of deer for each county are found in the 61-70 pound dressed weight class.

b. The average dressed weight for all deer weighed is 73.77 pounds.

c. There is a difference of 10.04 pounds in average weight of deer from the county having the highest average and of those from the county having the lowest average.

d. There are more deer found in the 4×4 antler point class in each of the counties than in any other division.

e. More deer have fewer than 4×4 antler points than have more.

f. The average weight of the deer varies from county to county.

g. The number of antler points also varies from county to county.

h. In weight groups containing ten or more individuals all the body measurements made show an increase with the increase in weight except the distance between burrs, and head and tail length.

i. The closest relationship seems to exist between the increase in weight, zygomatic breadth, and length of hind foot.

4. Data procured from the shooting preserve record books and the 1935 Department of Agriculture Census show that:

a. The county having the lowest average weight of deer has the largest number of deer killed per acre on its shooting preserves.

b. The county having the highest average weight of deer has the smallest number of deer killed per acre on its shooting preserves.

c. The county having the largest number of acres per animal unit has also the highest average weight of deer killed.

d. There are 86 ranches which have a deer kill of one or more per 100 acres.

CONCLUSIONS AND RECOMMENDATIONS

There are indications of unbalanced sex and age composition of the deer herd on some ranches. At least 86 ranches in four counties have an overpopulation of deer. The opinion of hunters that deer are becoming smaller may be a result of the killing of more immature bucks or of scarcity of food or both. There is a great need for research on grazing problems as they affect both deer and livestock. The trend in the age and size of the deer cannot be determined until more records for different seasons are available.

LITERATURE

JOHNSON, FRED W.
1937. Deer weights and Antler Measurements in Relation to Population Density and Hunting Effort. Trans. Second N. A. Wildlife Conference, pp. 446–457.

LEOPOLD, ALDO.
1933. Game Management, Charles Scribner's Sons, New York.

PARK, BARRY C.
1938. Deer Weights and Measurements on the Allegheny National Forest. Trans. Third N. A. Wildlife Conference, pp. 261–279.

TEXAS GAME, FISH, AND OYSTER COMMISSION.
1937. Game, Fish, and Oyster Laws of the State of Texas.
1938. Annual Report for 1937–1938.

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A SIMPLE AND EFFECTIVE LIVE TRAP FOR SMALL MAMMALS[1]

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A live trap for small mammals that is highly effective yet simple and inexpensive to build has been in use by the staff members and students of the Laboratory of Vertebrate Genetics during the last four years. The need for such a trap in many investigations of wildlife problems and other ecological studies of small mammals makes desirable a description of this trap. The "36" model, as this trap is designated, has proved the most efficient and practical of several types of live traps developed by Lee R. Dice and his associates and students. The author has used the "36" model trap extensively during the last four years, and consequently has been asked by Dr. Dice to prepare the present description.

The essential features of the trap are shown in Figure 1. The treadle is balanced a little back of the middle, so that the front edge of the treadle remains down, until the animal to be caught has reached the back part of the trap. The animal is then usually far enough inside the trap so that when the door falls it will not strike the back of the animal and thus fail to close completely. From one side of the treadle, at its axis, rises a stiff wire (A). This wire has a loop on its upper end which engages a loop of the trigger (B). The trigger wire is supported by a wire loop suspended from the roof of the trap. When the trap is set the trigger wire extends under the back edge of the door, preventing it from falling. When an animal enters the trap and steps on the back of the treadle, the trigger wire is pulled backward and the door falls. As the door falls a wire lock (C) drops into position behind it so that the door then cannot be opened either from the inside or outside until the lock is raised again. The lock, or drop wire, is a U-shaped piece of wire, swung on each side from a hole in the side of the trap near the top. When the door is in the open position the lock is above it. The door is slightly curved, so that the lock wire in dropping into position follows the arc of the door. This prevents any considerable amount of play between the lock and the door, when the door is closed. The door is slightly longer than the opening to the trap, and its bottom edge when closed, therefore, rests on the bottom of the trap, making it impossible for an animal to push out the door from the inside. A small piece on the lower end of the door is bent back at a right angle, so that the lock wire cannot fall below the lower edge of the door.

A wire across the trap near the rear door supports cotton nesting material and keeps it away from the working parts until after the animal has been caught. The back door slides in grooves in the top and bottom of the box, and is locked with a simple wire catch.

The box part of the trap may be made of any of several types of material; the most satisfactory to date has been oil-tempered pressed wood, of

[1] Contribution from the Laboratory of Vertebrate Genetics, University of Michigan

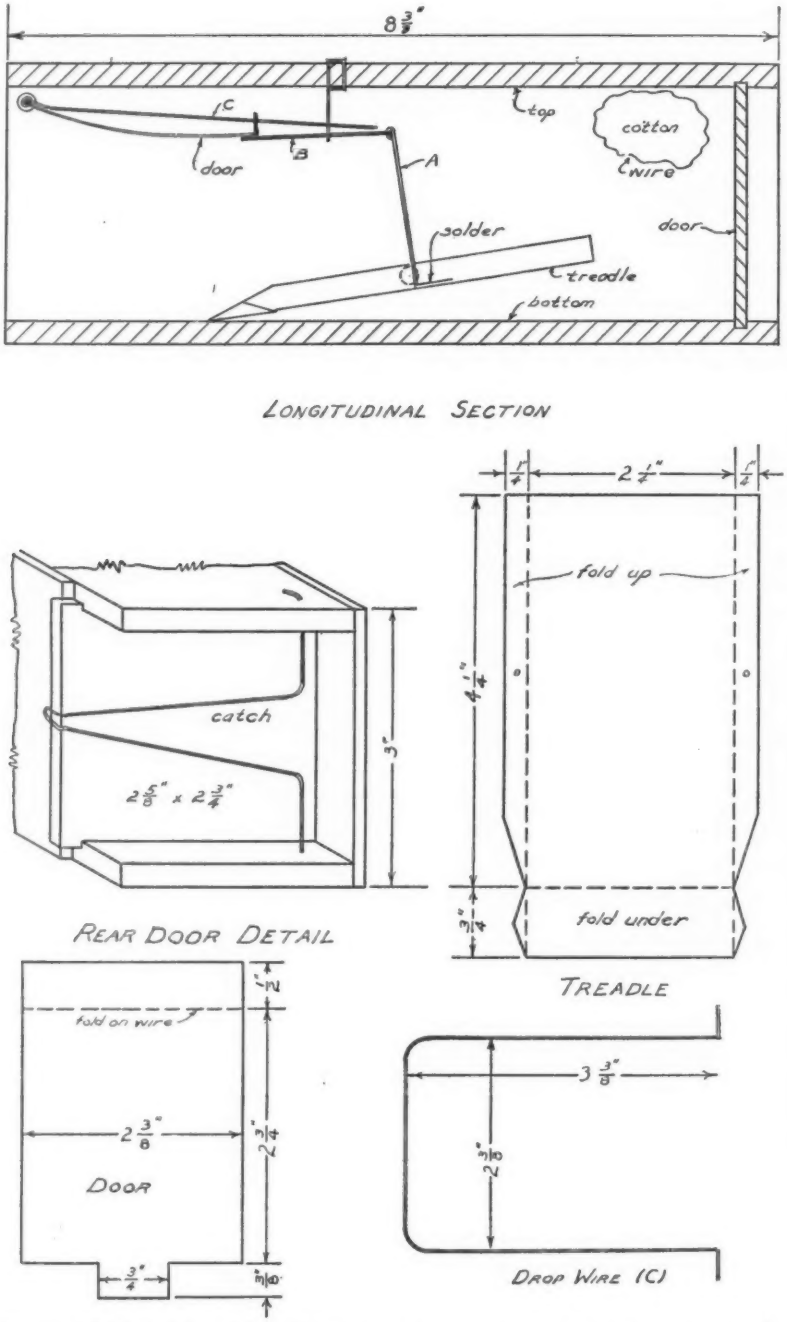

Fig. 1. Essential features of "36" model trap, with details of construction. (Drawn by P. F. Blair, Jr.).

which the trap shown in Figure 1 is made. The pressed wood is superior to metal in that it gives better insulation against heat and cold. It has the disadvantage of greater bulk and weight. Boxes of ¼ inch, oil-treated ponderosa pine also have been used. These provide better insulation than the pressed wood traps, but they warp badly under most field conditions and are more bulky than the pressed wood. Moreover, some small mammals, such as the meadow vole (*Microtus pennsylvanicus*) and wood mouse (*Peromyscus leucopus*) are able to gnaw their way out of the pine traps. With the pressed wood traps, the smooth surface of the material is turned in, and there has been no difficulty with mice gnawing this material.

The materials necessary for building one "36" model trap are listed below:

Side	1 piece oil tempered pressed wood	$\frac{1}{8}$″ thick×3″×8″
Side	1 piece oil tempered pressed wood	$\frac{1}{8}$″ thick×3″×8$\frac{3}{8}$″
Top and bottom	2 pieces oil tempered pressed wood	$\frac{1}{4}$″ thick×2$\frac{1}{2}$″×8$\frac{3}{8}$″
Back door	1 piece oil tempered pressed wood	$\frac{1}{8}$″ thick×2$\frac{5}{8}$″×2$\frac{1}{4}$″
Front door	1 piece #28 gauge galvanized sheet metal	3$\frac{5}{8}$″×2$\frac{3}{8}$″
Treadle	1 piece copper bearing (40 pound coating)	5″×2$\frac{1}{4}$″
Front door carrier	1 piece #14 galvanized wire	3$\frac{1}{2}$″ long
Drop wire	1 piece #16 galvanized wire	10$\frac{1}{4}$″ long
Trigger carrier	1 piece #18 galvanized wire	2″ long
Treadle carrier	1 piece #18 galvanized wire	3$\frac{1}{2}$″ long
Upright on treadle	1 piece #16 galvanized wire	2$\frac{3}{4}$″ long
Trigger wire	1 piece #18 galvanized wire	2″ long
Cotton carrier	1 piece #18 galvanized wire	3$\frac{1}{2}$″ long
Back door lock	1 piece #16 galvanized wire	9″ long
Wood screws	12 #3 round-headed, blued	$\frac{3}{8}$″ long
Brass washers	8 #4	

The box is glued together with waterproof casein glue, and has three screws to each joint. Holes are bored for the various wires, grooves cut for the back door, and the trigger carrier wire attached before the box is assembled. On the front door carrier wire, two brass washers are placed between each side of the door and the side of the box. Two washers also are placed between each side of the treadle and the side of the trap. After the front door is in place, the trigger wire and lock wire are adjusted to it. The trigger may be adjusted by bending its upright portion slightly forward or backward. The lock wire should be adjusted to fall free until it engages the bottom of the door. The back door should slide freely in its grooves, as there will be a small amount of swelling when the trap gets wet.

The trap of the size discussed here and illustrated in Figure 1 has proved satisfactory for the trapping of small mammals up to the size of the spotted ground-squirrel (*Citellus spilosoma*) and chipmunk (*Tamias striatus*). Larger traps, utilizing the same type of mechanism, may be used for larger animals. A trap, with a box having the dimensions of 4 × 4 × 13 inches and made of wire mesh has proved very satisfactory for mammals of the size of the plains woodrat (*Neotoma micropus*).

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NOTES ON THE ENDOPARASITES OF WISCONSIN PINNATED AND SHARP-TAILED GROUSE

B. B. Morgan and F. N. Hamerstrom Jr.

Study of the parasites of Wisconsin prairie chickens (*Tympanuchus cupido americanus*) and sharptails (*Pedioecetes phasianellus campestris*) was begun by Gross (1930). A second report can now be made, based on material gathered during the hunting seasons[1] of 1938 and 1939 and on a few incidental specimens acquired between December, 1938, and June, 1940.

Table 1 shows the type of material that has been examined for endoparasites and the dates of collection. It indicates also: the scope of the work and its shortcomings; the insufficient collections for both species; the inadequate spread of time involved; the fact that parasites of the digestive tract only were examined; and that complete digestive tracts were available in only 100 of the 177 specimens examined. Further, even among the so-called "complete" tracts some of the muscular gizzard walls could not be taken, as some hunters wanted them for food.

TABLE 1

TYPES OF MATERIAL EXAMINED FOR PARASITES AND DATES OF COLLECTION

Host Species	Materials examined for parasites	Oct. 1938	Dec. 1938	Jan. 1939	Feb. 1939	Mar. 1939	Apr. 1939	Sept. 1939	Oct. 1939	Nov. 1939	Mar. 1940	Apr. 1940	June 1940	Totals
Sharp-tailed grouse	Entire intestinal tract							54	8					62
	Stomach, crop, and gizzard only	59	1					4						64
	Totals	59	1					58	8					126
Pinnated grouse	Entire intestinal tract					2	1	4	22	4	2	3	1	39
	Stomach, crop, and gizzard only	9		1	2	1								13
	Totals	9		1	2	3	1	4	22	4	2	3	1	52

No evidence of infectious disease was encountered, although Gross (1930) found 2 cases of "blackhead" (*Histomonas meleagridis*) in Wisconsin prairie chickens. Several collections of ectoparasites were made, but the specimens have not as yet been identified.

[1] Viscera of hunter-killed birds were gathered as follows: by Frederick and Frances Hamerstrom, 42 prairie chickens and 37 sharptails; by the U. S. Forest Service, Chequamegon and Nicolet Forests, 63 sharptails; and by 12 private individuals 9 prairie chickens and 26 sharptails.

TABLE 2

ENDOPARASITES: PINNATED GROUSE

Parasite	*Habitat*	*Number birds infested*	*Number birds examined*	*Per cent birds infested*	*Number parasites in heaviest infestation*	*Per cent birds not parasitized*
Seurocyrnea colini[1]	gizzard	13			16	
Heterakis gallinae	ceca	8	39	20.5	32	
Rhabdometra nullicollis	small intestine	5	39	12.8	14	
Capillaria contorta	crop	5	52	9.6	12	
Ascaridia lineata	small intestine	2	39	5.1	11	
Choanotaenia infundibulum	small intestine	2	39	5.1	6	
Eimeria dispersa(?)[2]	fecal sample	2	39	5.1	few	
Eimeria sp.(?)[2]	fecal sample	1	39	1.9	few	
Capillaria sp.	crop	1	52	1.9	6	
Not Parasitized		22	39			56.4

[1] Since the muscular wall of some of the gizzards could not be saved for examination, the occurrence figures for *S. colini* and *C. spinosa* (Table 3) cannot be compared with the others or calculated on a percentage basis. By the same token, the grouping "not parasitized" does not take these two nematodes into consideration.

[2] Unsporulated oocysts. Since the genus *Isospora* has not been recorded in galliinaceous birds in the Western Hemisphere (Boughton, 1938), these oocysts were tentatively referred to the genus *Eimeria:* the provisional specific determination of *E. dispersa* was based on measurements of unsporulated oocysts (Tyzzer, 1929).

ENDOPARASITES

Tables 2 and 3 list the parasites that were found in the digestive tracts of the 2 species of grouse. Helminths were found by direct search and coccidial oocysts by the sugar flotation method (Benbrook, 1929).

In general, sharptails were more heavily parasitized than prairie chickens. This was true not only as to the number of individuals parasitized, but also for the number of species of parasites and the gross numbers of parasites found. As most of the sharptails were

TABLE 3

ENDOPARASITES: SHARP-TAILED GROUSE

Parasite	*Habitat*	*Number birds infested*	*Number birds examined*	*Per cent birds infested*	*Number parasites in heaviest infestation*	*Per cent birds not parasitized*
Seurocyrnea colini	gizzard	39			18	
Heterakis gallinae	ceca	19	62	30.6	48	
Ascaridia lineata	small intestine	12	62	19.4	12	
Choanotaenia infundibulum	small intestine	11	62	17.7	8	
Rhabdometra nullicollis	small intestine	9	62	14.5	14	
Eimeria dispersa(?)[2]	fecal sample	7	62	11.3	few	
Capillaria contorta	crop	12	126	9.6	20	
Cheilospirura spinosa[1]	gizzard	3	62		6	
Subulura strongylina	ceca	3	62	4.8	4	
Eimeria angusta[3]	fecal sample	3	62	4.8	few	
Not parasitized[1]		14	62			22.6

[1] See footnote 1, Table 2.
[2] See footnote 2, Table 2.
[3] Sporulated oocysts.

collected in northern Wisconsin,[2] and most of the prairie chickens in the central counties,[3] it is possible that this difference is due to a differential distribution of parasites within the state, similar to that found by Boughton (1937) in Minnesota. On the other hand, it may simply reflect the meagerness of the data.

Seurocyrnea colini was found in the greatest number of individuals of both prairie chickens and sharptails. Its incidence would have been even higher, had not some of the muscular gizzard walls been removed before the material was examined. Gross (1930) found this nematode in only 3 of 34 Wisconsin prairie chickens and in none of 28 Wisconsin sharptails. Boughton (1937) reported *S. colini* in 2 of 62 North Central States sharptails, both from South Dakota.

Heterakis gallinae in both grouse was second in point of frequency of parasitization and first as to the number of worms present in the heaviest infestations. Gross (1930) found this cecal nematode in half of his Wisconsin prairie chickens but in neither sharptails nor ruffed grouse (82 specimens) in Wisconsin, and considered its high incidence in prairie chickens evidence that this bird feeds on ground contaminated by poultry, especially turkeys. Boughton (1937) listed *H. gallinae* as a rare parasite in Minnesota; no sharptails, and only 3 of 560 ruffed grouse, were infested. Gross (1930) has already pointed out that *H. gallinae* is less important as a primary parasite of prairie chickens than as a carrier of *Histomonas meleagridis*, the causative agent of "blackhead."

Rhabdometra nullicollis (a tapeworm), reported by both Gross (1930) and Boughton (1937), was the third most common parasite found in prairie chickens, and among those most frequent in the sharptails. *Ascaridia lineata* and *Choanotaenia infundibulum* held third and fourth places, respectively, in frequency of infestation among the sharptails examined, but each occurred in only about 5 per cent of the prairie chickens. Both Gross (1930) and Boughton (1937) found *A. lineata* in the adult stage to be the most common parasite in the grouse that they examined. Mature *A. lineata* are relatively innocuous but the larvae (as reported by Ackert, 1930, in the common fowl) may be very injurious to young birds. *C. infundibulum* was the "common cestode" in Minnesota, found in both sharp-tailed and ruffed grouse (Boughton, 1937); but it did not occur in Gross's (1930) Wisconsin prairie chickens and sharptails.

The rather high incidence of coccidia, particularly among sharptails, is surprising. Gross (1930) found no coccidia; Boughton (1937) found one case of *Eimeria dispersa*, and one of *E. angusta*, in sharptails, and quoted Leslie and Shipley, Brinkman (1927), and Portal and Collinge to show how dangerous coccidiosis can be to grouse, particularly young birds.

The remaining parasites were found in relatively few instances, in each case

[2] Mainly Bayfield County; a few from Ashland, Burnett, Douglas, Forest, Oconto, Price, and Washburn Counties in northern Wisconsin; and a few from Clark, Juneau, and Wood Counties in Central Wisconsin.

[3] Mainly Adams County; a few from Jackson, Juneau, Marquette, and Waushara Counties in central Wisconsin; and a few from Burnett County.

in less than 10 per cent of the prairie chickens and sharptails examined. Two of them, however are known to have considerable pathological importance: Cram (1930) reported that bob-whites have been killed by *Capillaria contorta* and ruffed grouse by *Cheilospirura spinosa*. The former was not reported by either Gross (1930) or Boughton (1937), but the latter was found by both these investigators to be common in ruffed grouse and present in sharptails. *Subulura strongylina*, found in about 5 per cent of the sharptails and in no prairie chickens, is of unknown pathogenicity, Cram (1931). This cecal nematode was not found by Gross (1930); Boughton (1937) reported this parasite from a single ruffed grouse, but not from sharptails.

Heavy infestations of *Railletina* sp. (a tapeworm) were found in sharptails and in one prairie chicken by Gross (1930) but appeared in neither of these grouse during this study.

Several of the findings here recorded constitute new host records. They are: For sharptails—*Capillaria contorta, Subulura strongylina;* and for prairie chickens—*Rhabdometra nullicollis, Choanotaenia infundibulum,* and *Capillaria contorta.* No species of *Eimeria* has been reported from prairie chickens (Boughton and Volk, 1938), but the unsporulated oocysts listed in Table 2 constitute an imperfect record at best.

No individual, prairie chicken or sharptail, was heavily parasitized, and none showed marked damage due to parasitism. As already pointed out, however, a number of the parasites are potentially dangerous in heavier infestations. All are probably more of a menace to young birds than to old.

CONTROL MEASURES

Some of these parasites have direct life cycles, some require intermediate hosts, while some have not been effectively investigated. The first category includes the species of *Eimeria, A. lineata, H. gallinae, S. strongylina,* and *C. contorta.* In the second division, *C. spinosa* requires a grasshopper (*Melanoplus femur-rubrum, M. differentialis*) as intermediate host, and *C. infundibulum,* the house fly (*Musca domestica*) and perhaps other insects. The intermediate hosts of *R. nullicollis* and *S. colini* occurring in nature, are unknown. A high proportion of the parasites thrive equally well in domestic chickens and turkeys to which they owe much of their prevalence.

Repression of parasitization by control of the intermediate host, a method that has worked out so well in the case of the sheep liver fluke (*Fasciola hepatica*), offers little promise in connection with the grouse. Despite well established control programs, house flies are still abundant, and grasshoppers are eaten in quantity by both grouse.

Permanent feeding stations are a possible source of infestation by those forms with a direct life cycle. Changing the site of feeding stations from year to year might, therefore, be a worthwhile sanitary measure. On the other hand, feeding stations are used mainly in winter, when the chance of spread of parasites is at a minimum. The possible role of feeding stations in the spread of parasites has not been explored.

Probably the most important single measure in the control of parasites is to keep prairie chickens and sharptails as far as possible from ground contaminated by domestic poultry. It is perhaps

futile to hope that any marked reduction can be achieved in the practice of giving poultry free range. Hamerstrom (unpublished) has evidence to show that grain is necessary for prairie chickens in winter; from the standpoint of sanitation, grain should be planted (or left unharvested) at a distance from the farmyard.

SUMMARY

1. One hundred and twenty-six sharptailed grouse (*Pedioecetes phasianellus campestris*) and 52 prairie chickens (*Tympanuchus cupido americanus*) were examined for endoparasites.

2. Nematodes found in prairie chickens included *Seurocyrnea colini* (gizzard), *Heterakis gallinae* (ceca), *Capillaria contorta* (crop), *Capillaria sp.* (crop), and *Ascaridia lineata* (small intestine). Nematodes found in sharptails include the above-mentioned parasites and in addition *Cheilospirura spinosa* (gizzard), and *Subulura strongylina* (ceca).

3. Tapeworms recorded in this survey from prairie chickens and sharptails were *Rhabdometra nullicollis* and *Choanotaenia infundibulum.*

4. Several species of coccidia were found by fecal examination from both prairie chickens and sharptails.

LITERATURE CITED

ACKERT, J. E.
1930. Recent developments of the importance and control of the intestinal roundworm *Ascaridia lineata* of chickens. Proc. World's Poultry Congress, London. 80: 533–541.

BENBROOK, E. A.
1929. Fecal examination for evidence of parasitism in domestic animals. Iowa State College, Vet. Pract. Bul. 9 (1): 1–56.

BOUGHTON, D. C.
1938. Avian hosts of the genus Isospora (Coccidiida). Ohio Journ. Sci. 38: 149–163.

BOUGHTON, D. C. AND VOLK, J. J.
1938. Avian hosts of Eimerian coccidia. Bird-Banding 9: 139–153.

BOUGHTON, R. V.
1937. Endoparasitic infestations in grouse, their pathogenicity and correlation with meteoro-topographical conditions. Univ. Minn. Ag. Exp. Sta. Tech. Bul. 121.

BRINKMAN, A.
1927. Grouse disease in Norway. Nature. 120: 567–568.

CRAM, E. B.
1930. Parasitism in game birds. Trans. 17th Amer. Game. Conf.: 203–206.
1931. Nematodes (roundworms) in quail. In Stoddard, H. L. "The Bob-white Quail": 240–296.

GROSS, A. O.
1930. Progress report of the Wisconsin Prairie Chicken Investigations. Wis. Conser. Comm.: 1–112.

TYZZER, E. E.
1929. Coccidiosis in gallinaceous birds. Amer. Journ. Hygiene. 10: 1–115.

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BLOOD PARASITES OF SOME MAINE WATERFOWL

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An opportunity to examine wild waterfowl in Maine for blood parasites was presented during the summer of 1939 by the Maine Pittman-Robertson Wildlife Restoration Project. A major objective of the survey was to determine the prevalence of the blood protozoan *Leucocytozoon*. This parasite was shown by O'Roke[2] (1934) to be responsible for heavy losses among wild ducks in Michigan. O'Roke found it occurring widely in ducks from other central, and also from western and southern, states. In addition, Herman (1938) reported *Leucocytozoon* in wild ducks on Cape Cod, Massachusetts.

Previous to the present survey we had some evidence that this parasite is present in the waterfowl of Maine. One outbreak occurred in 1935 in a flock of domestic ducks near the town of Orono. The ducks had been brought in from Massachusetts about a month earlier. The owner, not being familiar with the malady, brought specimens to Dr. J. F. Witter, Animal Pathologist at the University of Maine. It was not certain that the parasites had been acquired after their arrival in this state. In June 1938 blood smears obtained by the Wildlife Research Department of the University of Maine, from two wild black ducks near Orono, revealed *Leucocytozoon*. One of the birds, a duckling, was examined, banded, and released. It survived the infection and was caught late the following fall near Orono in a muskrat trap. Other ducks examined that summer, one golden-eye and two ring-neck ducks, were negative for blood parasites.

In the summer of 1939 banding and other operations in connection with the project mentioned gave the desired opportunity for the collection of blood smears from waterfowl. Study of the smears has produced a number of new host records for species of parasites already described as well as for some possibly undescribed parasites. In addition, some information was obtained in the comparative prevalence of infections in adult and young birds and in different species of ducks. Since no previous survey of this type has been made in the region it seems desirable at this time to present the findings.

Materials and Methods

The waterfowl examined in this survey were all obtained from the central part of Maine in Penobscot, Somerset, and Piscataquis counties, Most of the blood smears were made from live birds trapped during banding operations. Some of the birds were caught on the breeding grounds while others were taken on nearby waterways. In the fall a number of smears were obtained from birds shot during the hunting season.

Efforts were made to catch as many ducklings on the breeding grounds as

[1] A joint contribution of the Department of Zoology of the University of Maine and the Pittman-Robertson Wildlife Restoration Project of the Maine Department of Inland Fisheries and Game.

[2] The species name *L. anatis* Wickware was accepted by O'Roke (1934). Herman (1938) is of the opinion that the correct name is *L. simondi* Mathis and Leger.

possible. This turned out to be an exceedingly difficult task because of the diving ability of most of the ducklings. The greater share of the birds were caught in the fall by live-trapping of immature and adult birds.

Blood was procured from the live birds by making an incision in a toe. The smears were stained with Wright's stain and each slide examined for at least 15 minutes and usually much longer before being discarded as negative.

RESULTS

Blood smears from 130 waterfowl belonging to nine species were examined. Of these birds, 103 or 79% were found infected with representatives of one or more of three blood parasite groups, the protozoan genera, *Leucocytozoon* and *Haemoproteus*, and the Nematode group *Microfilaria*. The relative incidence of the parasites in the species of hosts is shown in Table 1.

Blood parasites were found in all of the nine species of birds with the exception of the lesser scaup, only two of which were collected. *Haemoproteus* was present in four species, *Leucocytozoon* in six, and *Microfilaria* in six. All three parasite groups were found in the black ducks and wood ducks. *Haemoproteus* and *Microfilaria* were present in the ring-neck duck and coot, *Leucocoytozoon* and *Microfilaria* in the hooded merganser and green-winged teal, and *Leucocytozoon* alone in the American merganser and American golden-eye.

No parasites were found in 10 of the 77 wood ducks. Of single infections there were 8 of *Leucocytozoon*, 11 of *Haemoproteus*, and one of *Microfilaria*. Of double infections there were 16 combining *Haemoproteus* and *Leucocytozoon*, six of *Leucocytozoon* and *Microfilaria*, and seven of *Haemoproteus* and *Microfilaria*. There were 16 triple infections.

No parasites were found in two of the twenty-nine black ducks. Of single infections there were 12 of *Leucocytozoon*, none of *Haemoproteus*, and one of *Microfilaria*. Of double infections there were six combining *Haemoproteus* and *Leucocytozoon*, eight of *Leucocytozoon* and *Microfilaria*, and none of *Haemoproteus* and *Microfilaria*. There were no triple infections.

LEUCOCYTOZOON

All of the leucocytozoa found in the ducks in this survey apparently belong

TABLE 1

RELATIVE INCIDENCE OF BLOOD PARASITES IN INFECTED BIRDS

Common name	Scientific name	Number examined	Haemoproteus		Leucocytozoon		Microfilaria	
			No.	%	No.	%	No.	%
Wood Duck	Aix sponsa	77	50	64	46	59	30	38
Black Duck	Anas rubripes	29	6	20	26	89	9	31
Ring-neck Duck	Nyroca collaris	6	3	50	0	—	1	16
American Merganser	Mergus merganser americanus	7	0	—	2	28	0	—
Hooded Merganser	Lophodytes cucullatus	3	0	—	2	66	1	33
American Golden-eye	Glaucionetta clangula americana	3	0	—	1	33	0	—
Green-winged Teal	Nettion carolinense	1	0	—	1	100	1	100
Coot	Fulica americana	2	1	50	0	—	1	50
Lesser Scaup	Nyroca affinis	2	0	—	0	—	0	—

to the same species and agree in morphology with the form *Leucocytozoon anatis* Wickware studied by O'Roke (1934).

As pointed out by Coatney and Roudabush (1937) the host-index for leucocytozoa of ducks is incomplete because of the fact that workers have frequently neglected to indicate the species of ducks examined.

Our records of leucocytozoa in the wood duck (*Aix sponsa*), American merganser (*Mergus merganser americanus*), hooded merganser (*Lophodytes cucullatus*), American golden-eye (*Glaucionetta clangula americana*) and green-winged teal (*Nettion carolinense*) appear to be additions to the list of hosts.

In the literature there are more data on *Leucocytozoon* in black ducks than in any other species. O'Roke (1934) mentions finding a 100 per cent infection of wild black ducks in Emmet and Cheboygan counties, Michigan in 1930 and a 28 per cent infection among black and mallard ducks in Munuskong Bay north of the Straits of Mackinac in 1930. Other groups of ducks were examined but the species involved are not listed. Herman (1938 a & b) found in blood smears from a group of 85 black ducks from Cape Cod, Massachusetts a little more than 10 per cent showing leucocytozoa. In a second paper Herman (1938b) records infections in the red-breasted merganser and blue-winged teal.

Maine is so heavily infested with the black fly (*Simulium venustum*), the transmitting agent for *Leucocytozoon*, that one would logically expect a high incidence of the parasite in ducks that breed in the state. The 89% infection here reported is high and if the disease is as destructive as was recorded in Michigan by O'Roke (1934), it may cause significant losses among our black ducks.

Seventy-seven wood ducks showed only a 59% infection with *Leucocytozoon*. Although these data suggest a difference in reaction by the two species to the infection they are probably insufficient to be statistically conclusive. The relative susceptibility of different species of wild ducks to *Leucocytozoon* has not been studied. Information on that point would be of value, however, in the management and propagation of wild ducks. Domestic ducks appear to be highly susceptible to the disease. O'Roke reports that farmers found it impractical to raise ducks in Cheboygan County, Michigan because of *Leucocytozoon* infection. To what extent farmers have encountered this difficulty in Maine is not known, as a relatively small number of domestic ducks are raised here. As previously stated one epidemic has already come to our attention. In one other instance a farmer reported the death of young ducks but did not submit specimens.

A comparison of the prevalence of *Leucocytozoon* among wood and black ducks of different ages (see Table 2) reveals certain differences. Five out of five black ducklings three to seven weeks old were infected with *Leucocytozoon*. Of the 24 adults, 87 per cent were parasitized. All wood ducklings under two weeks old were negative while those four to five weeks old showed *Leucocytozoon*. Juvenile wood ducks were 64 per cent, and adults 55 per cent, infected.

Although the numbers of birds examined are too small to be statistically significant, the data suggest that 100

TABLE 2

RELATIVE PREVALENCE OF *LEUCOCYTOZOON* AND *HAEMOPROTEUS* IN YOUNG AND OLD WOOD DUCKS AND BLACK DUCKS

Age	Number examined	Leucocytozoon		Haemoproteus	
		No.	%	No.	%
Black duck					
adult	24	21	87	2	8
ducklings, 3 to 7 weeks	5	5	100	4	80
Wood duck					
adult	18	10	55	6	33
juvenile	53	34	64	44	83
ducklings					
1 to 2 weeks	4	0	0	0	0
4 to 5 weeks	2	2	100	2	100

per cent of the Maine wood and black ducks become infected while they are young ducklings. O'Roke (1934) found that the parasites appear in the blood seven days after the duck has been bitten by the transmitting fly. The one to two weeks old wood ducklings that we examined presumably showed no leucocytozoa in the blood either because they had not been bitten by infected flies as yet or if they had, insufficient time had elapsed for the parasites to appear in the blood.

If 100 per cent of our young ducks become infected, then the greater per cent of positive blood smears from the adult black ducks indicate that there is a greater tendency for the infection to remain active in the black duck than in the wood duck.

It is not possible to say that the ducks showing no parasites in the blood are entirely free from the parasites because the infection may persist in a latent condition in the internal organs.

Two of the black ducklings were heavily infected, the number of parasites in the smears being comparable to that in local domestic ducks showing symptoms; on the average the smears had about one parasite per eight fields under oil immersion. Heavy infections were also found in a young hooded merganser and in one young American merganser.

HAEMOPROTEUS

Herman (1938 a & b) reported for the first time a *Haemoproteus* from a North American duck. He found this organism in six of 85 black ducks examined on Cape Cod but gave no specific name.

The prevalence of *Haemoproteus* in the ducks we examined is shown in Table 1. The wood duck, ring-neck, and coot are apparently new hosts of record. The wood ducks were more commonly infected with this parasite than were the black ducks—a reversal of the situation found with respect to *Leucocytozoon*.

Four out of five black ducklings three to seven weeks old, and only two out of 24 adults (Table 2) yielded *Haemoproteus*. Four wood ducklings under two weeks old were negative but two of the four- to five-weeks-old birds were infected. Coatney (1933) reports that in pigeons, *Haemoproteus columbae* appears in the blood 28 to 30 days after the birds have been bitten by the pigeon fly vector (*Pseudolynchia maura*). If it

requires that long for the duck haemoproteus to develop, transmission to the ducklings must take place in some cases soon after hatching, in order for the parasite to be apparent in birds three to four weeks old. The vector of the duck haemoproteus is not known. In general the infections were light, with about one parasite per three or four microscope fields under oil immersion.

Our study showed a higher per cent of infections in juvenile than in adult wood ducks (Table 2) In contrast, Herman (1938) found *Haemoproteus* more prevalent in adults than in juveniles of a series of 81 adult and 39 juvenile chipping sparrows.

The effect of *Haemoproteus* on ducks has not been investigated. Illness from infections with *Haemoproteus* has been noted in pigeons by Coatney (1933); and O'Roke (1932) in a study of *Haemoproteus lophortyx* in California valley quail noted illness and some fatalities due to this parasite.

MICROFILARIA

Microfilaria were found in 38 per cent of the wood ducks, 31 per cent of the black ducks, one of six ring-necked ducks, one of three hooded mergansers, one green-winged teal and one of two coots.

Microfilaria have been reported from a duck from Long Island, N. Y. by Beaudette (1936) and in 8 out of 15 ducks from Illinois by Torrey, Thorp, and Graham (1934). The species of these infected ducks were not indicated.

Three morphologically distinct types of microfilaria were found in the Maine ducks. For purposes of discussion these may be designated as A, B, and C. Type A shows no evidence of a sheath. It is relatively short and stout (45 to 65 microns long and four to six microns in diameter). The posterior end has a short, narrowed, characteristically curved or slightly twisted tail. In some slides cross striations were apparent, particularly toward the posterior end. This type was found in all the species of birds carrying microfilaria.

Type B was found in two adult wood ducks. This form was long and slender (115 to 135 microns long by about four microns in diameter). A sheath could not be detected.

Type C was found in one adult wood duck. This is a large sheathed type (125 microns long by seven microns in diameter). The sheath extended 12 microns beyond the posterior end.

Morphologically, Type A appears to be the same as that reported by Torrey, Thorp, and Graham (1934); no sheath was apparent on our specimens nor was it shown on a microphotograph by these authors. Beaudette (1936) reported a sheathed form; it is possible, therefore, that our Type C may be the same as that he reported. Adult worms were not obtained by the previous workers nor by us.

To date, no reports show that these worms have had any apparent effect on the health of the infected birds.

Our studies show no microfilaria present in birds under seven weeks of age. The incidence of this parasite was light. In the comparative series of wood and black ducks the infection rates seem to indicate similar susceptibility.

OTHER INFECTIONS

Outstanding absentees from the list of parasites found in the blood of the Maine ducks studied are species of the

genera *Plasmodium* and *Trypanosoma*. Careful examination was made for these forms but none were found.

SUMMARY

1. Blood smears were obtained from 130 waterfowl of nine species. Except for a few taken during the hunting season, the birds were live-trapped during the summer and fall of 1939. Blood parasites were found in the wood duck (*Aix sponsa*), black duck (*Anas rubripes*), ring-neck duck (*Nyroca collaris*), American merganser (*Mergus merganser americanus*), American golden-eye (*Glaucionetta clangula americana*), hooded merganser (*Lophodytes cucullatus*), green-winged teal (*Nettion carolinense*), and coot (*Fulica americana*). No parasites were found in two lesser scaups (*Nyroca affinis*).

2. *Leucocytozoon* was found in 59 per cent of 77 wood ducks and 89 per cent of 29 black ducks. Since these two species came from the same area the evidence may indicate that black ducks are more prone to infection than the wood ducks. No birds under two weeks of age were found infected. One hundred per cent of the wood and black ducklings from three to seven weeks of age, however, were infected.

3. Additions to the list of hosts recorded for *Leucocytozoon* are the wood duck, American merganser, hooded merganser, American golden-eye, and green-winged teal.

4. *Haemoproteus* was found in 64 per cent of 77 wood ducks and 20 per cent of 29 black ducks which may indicate that wood ducks are the more prone to infection. Infections of *Haemoproteus* were found also in ring-necked ducks and coots. Ring-neck ducks, wood ducks, and coots are additions to known hosts of *Haemoproteus*.

5. *Microfilaria* was found in 38 per cent of the wood ducks and 31 per cent of the black ducks, one of six ring-neck ducks, one of three hooded mergansers, one green-winged teal, and one of two coots. Three different types of microfilaria were found. The adult worms were not collected.

BIBLIOGRAPHY

BEAUDETTE, F. R.
1936. Microfilaria in a duck. Journ. Am. Vet. Med. Assoc. 89, N. S. 42: 5, 589–590.

COATNEY, G. R.
1933. Relapse and associated phenomena in the Haemoproteus infection of the pigeon. Amer. Journ. Hyg. 18: 1, 133–160.
1936. A check-list and host-index of the genus Haemoproteus. Journ. Parasit. 22: 1, 88–105.
1937. A check-list and host-index of the genus *Leucocytozoon*. Journ. Parasit. 23: 2, 202–213.

COATNEY, G. R., AND ROUDABUSH, R. L.
1937. Some blood parasites from Nebraska birds. Am. Midland Nat. 18: 6, 1005–1030.

HERMAN, C. M.
1938. Haemoproteus sp. from the common black duck Anas rubripes tristis. Journ. Parasit. 24: 1, 53–56.
1938a. The relative incidence of blood protozoa in some birds from Cape Cod. Trans. Am. Micr. Soc. 57: 2, 132–141.
1938b. Leucocytozoon anatis Wickware, a synonym for L. simondi Mathis and Leger. Journ. Parasit. 24: 5, 472–473.

O'ROKE, E. C.
1932. Parasitism of the California Valley quail by Haemoproteus lophortyx, a protozoan blood par-

asite. California Fish and Game. 18: 3, 223–238.

1934. A malaria-like disease of ducks caused by Leococytozoon anatis Wickware. Univ. Mich. School of Forestry Bul. 4: 1–44.

TORREY, J. P., THORP, F. JR., AND GRAHAM, R.

1934. A note on pathological changes encountered in wild ducks. Cornell Vet. 24: 4, 289–298.

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THE EFFECT OF FLUCTUATING WATER LEVELS ON THE MUSKRAT POPULATION OF THE ILLINOIS RIVER VALLEY

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Studies made along the Illinois River in 1939 and 1940 substantiate the findings of other investigators that fluctuating water levels have a marked bearing on muskrat populations. The effects of drought and floods in causing starving and drowning of muskrats and in increasing predation upon them have been pointed out by Errington (1937, 1938). The present paper deals with the direct, as well as the indirect, effects of drought and flood on the muskrat. Indirectly water levels affect this mammal in the Illinois River Valley by restricting the vegetation it depends upon for food and cover.

The area used for the present study was a navigation pool in the Illinois River and numerous bottomland lakes that flank the river for 140 miles between De Pue and Meredosia. These lakes, ranging in size from 10 to 6,500 acres, have a combined water surface of almost 56,000 acres. The majority of them rise and fall with the river, but in some, natural or artificial levees and dams permit varying degrees of resistance to flood and drought effects. High water usually occurs from February through May and low water from early August to October.

As a result of fluctuating water levels, there is a paucity of aquatic and marsh plant species in the area as a whole. Only a few species are able to tolerate the severe environmental pressure.

In 1938 and in 1939, the senior author made detailed maps of the plant species occurring in more than 20 bottomland lakes. In order to determine the relative value of the various species of plants to muskrats, the two authors made an enumeration of the muskrat houses in various vegetation types in February, 1940. As the lakes were ice covered, it was a simple matter to determine the composition of the houses at close range and to record the number of lodges in the various vegetation types. The writers have grouped the lakes in the Illinois Valley into three major classes, in relation to environmental conditions and vegetation. The first class has stable waters, except during flood stages; the second has semistable waters, the water being high during flood times, and at other times lower than in lakes of the first class but higher than in lakes of the

TABLE 1

AREAS OF LAKES OF DIFFERENT TYPES, FALL, 1939, IN THE ILLINOIS RIVER VALLEY, BETWEEN OTTAWA AND MEREDOSIA, AND THOSE COVERED IN THIS STUDY

Type of water level	Area, Ottawa-Meredosia		Area covered in study	
	Acres	Per cent	Acres	Per cent
Stable	5,680	10.2	4,300	37.2
Semistable	6,750	12.2	3,644	31.5
Fluctuating	43,000	77.6	3,623	31.5

[1] The writers are indebted to Lee E. Yeager and Arthur S. Hawkins and others of the Illinois Natural History Survey for constructive criticism.

third; and the third class has fluctuating water levels, the water rising and falling with the river.

Table 1 records the areas of the three types of lakes found in the Illinois River Valley between Ottawa and Meredosia together with those covered during the course of this study. Lakes with fluctuating water levels greatly predominate in area over lakes with stable and semistable waters.

EFFECTS OF WATER LEVELS

Table 2 summarizes the number of muskrat houses per acre of emergent vegetation for lakes with stable, semistable, and fluctuating water levels. There were nearly six times as many in lakes with a stable, as in those with a semistable, water level and there were twice as many lodges per acre in lakes with a semistable, as in those with a fluctuating, water level. The acreage considered is that of vegetation, not the total. Lakes with a stable water level were considerably deeper than the others, and therefore, contained less emergent vegetation.

TABLE 2

RELATION OF TYPES OF WATER LEVEL TO EMERGENT VEGETATION AND ABUNDANCE OF MUSKRAT HOUSES

Type of water level	*Acres covered in study*	*Acres of emergent vegetation*	*Houses per acre of emergent vegetation*
Stable	4,300	378	3.5
Semistable	3,644	2,716	0.6
Fluctuating	3,623	1,367	0.3

The data presented in Table 3 demonstrate the effect of water levels on the relative abundance of aquatic and marsh plants in the Illinois River Valley during 1939. Stable waters are conducive to the development of submerged and floating aquatic plants, such as sago pondweed (*Potamogeton pectinatus*), longleaf pondweed (*P. americanus*), and coontail (*Ceratophyllum demersum*). In lakes with fairly stable water levels, river bulrush (*Scirpus fluviatilis*), American lotus (*Nelumbo lutea*), marsh smartweed (*Polygonum muhlenbergii*), and coontail predominate. Lakes with severely fluctuating water levels contain, in quantity, only such tolerant species as American lotus and river bulrush.

The data presented in Table 2 compared with those in Tables 4–12 inclusive, show that there is a greater difference in the abundance of muskrat houses per acre due to changing water levels than is due to variations in type of marsh vegetation. This would indicate that the direct effect of fluctuating water levels on the muskrat population is greater than its indirect effect through altering the composition of the vegetative habitat.

INFLUENCE OF DEPTH OF WATER

The optimum depth of water for muskrat lodge construction ranges between 12 and 18 inches, with 6 inches about the minimum and 24 inches approaching the maximum. The optimum depth for the growth of cattail, river bulrush, marsh smartweed, and wild rice coincides, for the most part, with that for lodge construction. On the other hand, the optimum depth for American lotus, 18 to 40 inches, is greater, and this may partially account for the lower number of lodges in this vegetation.

Because of the diversity of factors affecting the muskrat population in each lake, it is deemed best to treat the bod-

TABLE 3

AQUATIC PLANTS AND THEIR RELATIVE ABUNDANCE, EXPRESSED IN PERCENTAGE OF THE TOTAL ACREAGE OF THE PLANTS, AUGUST, 1939. LAKES WITH THREE TYPES OF WATER LEVEL, STABLE, SEMISTABLE, AND FLUCTUATING, ARE REPRESENTED

Species	Relative abundance in lakes, per cent			Per cent of total acreage
	Stable	Semi-stable	Fluctu-ating	
River bulrush (Scirpus fluviatilis)	0.6	21.4	14.1	36.1
American lotus (Nelumbo lutea)	0.1	16.3	12.0	28.4
Marsh smartweed (Polygonum muhlenbergii)	1.6	4.6	1.8	8.0
Coontail (Ceratophyllum demersum)	4.5	3.1	trace	7.6
Sago pondweed (Potamogeton pectinatus)	4.2	—	0.2	4.4
Wild millet (Echinochloa crusgalli)	—	—	4.1	4.1
Broad-leaved arrowhead (Sagittaria latifolia)	0.7	0.3	1.2	2.2
Longleaf pondweed (Potamogeton americanus)	1.5	—	trace	1.5
Water hemp (Acnida tuberculata)	—	—	1.5	1.5
Rice cutgrass (Leersia oryzoides)	—	0.8	0.2	1.0
White water lily (Castalia tuberosa)	—	0.9	—	0.9
Wild rice (Zizania aquatica)	—	0.8	—	0.8
Bushy pondweed (Naias guadalupensis)	0.8	trace	—	0.8
Water weed (Philotria canadensis)	0.7	—	—	0.7
Nut grass (Cyperus strigosus)	—	—	0.5	0.5
Giant burreed (Sparganium eurycarpum)	—	0.1	0.3	0.4
Mud plantain (Heteranthera dubia)	0.3	—	—	0.3
Spike rush (Eleocharis palustris)	—	—	0.2	0.2
Cord grass (Spartina michauxiana)	—	0.2	—	0.2
Cattail (Typha latifolia)	0.2	—	—	0.2
Pickerel-weed (Pontederia cordata)	—	0.1	—	0.1
Marsh mallow (Hibiscus militaris)	—	—	0.1	0.1
Reed cane (Phragmites communis)	—	trace	—	—
Nodding smartweed (Polygonum lapathifolium)	—	trace	trace	—
Cockelebur (Xanthium)	—	—	trace	—
	15.2	48.6	36.2	100.0

ies of water separately. So doing, it is possible to compare directly the value of each species of plant to muskrats, as determined by the number of houses per unit area.

LAKES WITH STABLE WATER LEVELS

Starved Rock Pool was impounded by a dam built to improve navigation in the Illinois river, and due to the dam, the water level at most seasons is stable. In Table 4, the more important aquatic plants and the number of muskrat lodges in each plant zone are recorded. Preferred sites for building were provided by: (1) Cattail (*Typha latifolia*) and (2), river bulrush (*Scirpus fluviatilis*). Other emergent plants failed to attract house-building muskrats. Lodges placed in the zone of cattails were constructed almost entirely of those plants, while houses among bulrushes contained stems not only of bulrush but of cattail as well.

Lake Chautauqua, a federal wildlife refuge and former drainage district, is inclosed by levees that maintain the water, except during spring floods, at a constant level. The most favored vegetation for muskrat lodges was river bulrush, which formed almost 12 per cent of the vegetation and harbored an aver-

TABLE 4
ABUNDANCE OF VEGETATION AND MUSKRAT HOUSES, STARVED ROCK POOL, WINTER 1939–40

Species of plant	Vegetation		Number of houses	
	Acres	Per cent	Total	Per acre
Cattail	42.0	57.9	282	6.7
River bulrush	4.0	9.6	12	3.0
Broad-leaved arrowhead	18.6	25.6	—	—
Nodding smartweed	2.5	3.4	—	—
Coontail	2.0	2.8	—	—
Giant burreed	0.5	0.7	—	—

age of 7.2 houses per acre. Marsh smartweed (*Polygonum muhlenbergii*), comprising about half of the emergent vegetation, had 5.3 lodges per acre. American lotus (*Nelumbo lutea*), growing in deeper water, supported 4.9 houses per acre. No lodges were found in the broad-leaved arrowhead beds.

TABLE 5
ABUNDANCE OF VEGETATION AND MUSKRAT HOUSES, LAKE CHAUTAUQUA, WINTER 1939–40

Species of plant	Vegetation		Number of houses	
	Acres	Per cent	Total	Per acre
River bulrush	36	11.8	261	7.2
Marsh smartweed	159	52.1	842	5.3
American lotus	78	25.6	14	4.9
Broad-leaved arrowhead	32	10.5	—	—

Muskrat lodges in beds of river bulrush were constructed almost entirely of the stalks and woody tubers of that species. Many of the houses in the smartweed zone included masses of coontail packed in among the smartweed stems. Coontail was added to houses composed of the stems, leaves, and seed pods of the American lotus.

LAKES WITH SEMISTABLE WATER LEVELS

As recorded in Table 6, river bulrush beds comprised nearly 70 per cent of the aquatic and marsh vegetation of Rice Lake. Here we found that more muskrat lodges were placed in the American lotus-coontail zone than in the river

TABLE 6
ABUNDANCE OF VEGETATION AND MUSKRAT HOUSES, RICE LAKE, WINTER 1939–40

Species of plant	Vegetation		Number of houses	
	Acres	Per cent	Total	Per acre
Marsh smartweed	18.0	3.0	80	4.40
American lotus	64.0	10.7	698	4.30
Coontail	99.0	16.6		
River bulrush	414.0	69.3	176	0.42
White waterlily	2.0	0.3	—	—
Wild rice	0.5	0.1	—	—

bulrush community. This is believed due to the fact that in 1939 the water receded from the river bulrushes, and the muskrats were forced to seek the deeper water in which the American lotus and coontail grew. In previous years, the majority of houses at Rice Lake were built among the bulrushes.

It was noticed that few muskrats that placed their lodges among lotus plants ventured as far as 30 feet to obtain river bulrush material for house construction. Lodges composed of stems and leaves of lotus were small and lacked the stability of those constructed of cattails, bulrushes, and smartweeds.

Douglass Lake is an extensive bulrush marsh containing five large areas of

open water. The majority of muskrat lodges were situated along the edge of the open water.

The data summarized in Table 7 show that about the same density of lodges was found in both river bulrush and marsh smartweed areas, and that a lower frequency prevailed in wild rice and American lotus beds. Of 396 houses recorded on Douglass Lake, only 22 were constructed chiefly of lotus leaves and stems. The remaining 374 were composed largely of river bulrush with

TABLE 7

ABUNDANCE OF VEGETATION AND MUSKRAT HOUSES, DOUGLASS LAKE, WINTER 1939–40

Species of plant	Vegetation		Number of houses	
	Acres	Per cent	Total	Per acre
Marsh smartweed	21	1.3	6	0.28
River bulrush	1,350	80.5	352	0.27
Wild rice	81	4.8	16	0.20
American lotus	132	7.9	22	0.10
White waterlily	54	3.2	—	—
Coontail	40	2.3	—	—

wild rice stalks added to 46 houses and smartweed stems to 6.

The Cuba Island marsh contained an abundance of aquatic and semiaquatic plants, yet only marsh smartweed and American lotus stems were there utilized by muskrats in house construction. According to the data presented in Table 8, nearly twice as many lodges were made in smartweed as in lotus beds. Sixty-three houses were placed between growths of lotus and smartweed, and these were composed of both species. Rice cutgrass (*Leersia oryzoides*), an abundant emergent plant, was not utilized either for a house site or as building material.

TABLE 8

ABUNDANCE OF VEGETATION AND MUSKRAT HOUSES, CUBA ISLAND, WINTER 1939–40

Species of plant	Vegetation		Number of houses	
	Acres	Per cent	Total	Per acre
Marsh smartweed	175.0	39.7	172	0.98
American lotus	153.0	34.7	107	0.70
Rice cutgrass	73.5	16.7	—	—
Marsh cordgrass	18.0	4.1	—	—
Coontail	21.0	4.8	—	—

LAKES WITH FLUCTUATING WATER LEVELS

Of the four lakes—Siebolt's, De Pue, Goose, and Ingram—in the third class on which an enumeration of muskrat houses was made, only Goose Pond had slightly controlled water levels. Here, small dams raised the water in restricted areas during the fall. At Goose Pond, river bulrush comprised more than 80 per cent of all emergent plants. The information summarized in Table 9 indicates that marsh mallow (*Hibiscus militaris*) furnished better house sites than river bulrush. However, possibly the small sample or a local concentra-

TABLE 9

ABUNDANCE OF VEGETATION AND MUSKRAT HOUSES, GOOSE POND, WINTER 1939–40

Species of plant	Vegetation		Number of houses	
	Acres	Per cent	Total	Per acre
Marsh mallow	1.5	0.3	8	5.30
River bulrush	466.0	87.4	205	0.44
Broad-leaved arrowhead	18.0	3.4	5	0.29
American lotus	45.0	8.4	—	—
Giant burreed	2.0	0.4	—	—
Rice cutgrass	0.5	0.1	—	—

TABLE 10

ABUNDANCE OF VEGETATION AND MUSKRAT HOUSES, LAKE DE PUE, WINTER 1939–40

Species of plant	Vegetation		Number of houses	
	Acres	Per cent	Total	Per acre
River bulrush	45.0	74.4	4	0.1
Marsh smartweed	15.0	24.8	—	—
Marsh mallow	0.5	0.8	—	—

tion of lodges may have given an inaccurate impression of the importance of the mallow. No houses were found in the American lotus zone.

Lake De Pue is a long, narrow, shallow, body of water where environmental conditions are severe as water levels fluctuate greatly, turbidity is high, and pollution occurs. Frequently, the water recedes so far as to leave many river bulrush beds exposed during the summer and fall. Table 10 shows that in this lake there is a low density of muskrat houses in the bulrushes and a total absence of lodges in other types of vegetation.

The water level of Siebolt's Lake, like that of De Pue and other bottomland lakes, may fluctuate as much as 12 feet during the year. This fluctuation results in a paucity of aquatic and semi-aquatic vegetation, and in a low muskrat population. As in Lake De Pue, so in Siebolt's Lake all muskrat lodges were placed in the river bulrush zone.

TABLE 11

ABUNDANCE OF VEGETATION AND MUSKRAT HOUSES, SIEBOLT'S LAKE, WINTER 1939–40

Species of plant	Vegetation		Number of houses	
	Acres	Per cent	Total	Per acre
River bulrush	48.7	54.4	21	0.41
Marsh smartweed	31.0	34.6	—	—
Rice cutgrass	4.3	4.8	—	—
Water hemp	3.0	3.4	—	—
Cocklebur	2.5	2.8	—	—

Since American lotus forms about 93 per cent of the emergent vegetation at Ingram Lake (Table 12) it is not surprising that all muskrat lodges were in this plant zone. The scarcity of houses —0.1 per acre—is doubtless due to lack of suitable food and cover plants, and to changing water levels. All of the houses in this lake were composed entirely of stems, leaves, and seed pods of lotus.

TABLE 12

ABUNDANCE OF VEGETATION AND MUSKRAT HOUSES, INGRAM LAKE, WINTER 1939–40

Species of plant	Vegetation		Number of houses	
	Acres	Per cent	Total	Per acre
American lotus	642.0	93.8	72	0.11
Marsh smartweed	27.0	3.9	—	—
Barnyard grass	15.0	2.2	—	—
Broad-leaved arrowhead	0.5	0.1	—	—

In relating the abundance of aquatic and marsh plants with the food selections of waterfowl (as determined from the examination of over 1,800 duck gizzards by Harry G. Anderson, employed jointly by the Illinois Natural History Survey, the Illinois Department of Conservation, and the U. S. Bureau of Biological Survey), we find that the most abundant plants—namely, river bulrush and American lotus—are little utilized. Because these species compete with valuable waterfowl food plants for growing space, they are often consid-

ered noxious weeds. However, present data indicate that river bulrush and, to a lesser extent, American lotus are important to muskrats in the Illinois River Valley.

SUMMARY AND CONCLUSIONS

1. Muskrat populations are affected more by changing water levels than by types of marsh vegetation in the Illinois River Valley.

2. Vegetation upon which the muskrat depends for food and shelter is limited chiefly by seasonal changes in water levels.

3. Because of large open areas in lakes with stable water levels, emergent types of vegetation were less abundant than in lakes with semistable water levels; the latter bodies of water, therefore, contained more muskrat houses than those with stable levels.

4. Cattail communities, although making up only 0.2 per cent of the aquatic and marsh plants in the lakes mapped, supported more muskrat houses per unit area than other plants. Cattail was preferred to river bulrush for lodge construction.

5. River bulrush is little utilized by waterfowl for food and, therefore, is frequently a weed among waterfowl food plants. It is, however, the most abundant marsh plant in the Illinois River Valley and, as shown by the number of houses per unit area, is of great value to muskrats.

6. Marsh smartweed harbored more muskrat houses per unit area at Chautauqua, Douglass, and Rice lakes than did American lotus. Many houses constructed of marsh smartweed contained masses of coontail.

7. Wild rice amounted to only 0.8 per cent of the aquatic plants in the entire number of lakes studied, and it was relatively unimportant as building material for muskrat houses.

8. American lotus beds formed 28.4 per cent of the aquatic and marsh vegetation of the area studied in 1939. There were 50 per cent fewer lodges per unit area in this vegetation than in river bulrush or marsh smartweed in all lakes except Rice Lake, where the water had receded from the bulrush zone.

9. Other species of plants were unimportant in providing sites for muskrat houses. Coontail was added to many of those constructed of American lotus and marsh smartweed.

10. Muskrats used vegetation immediately surrounding the lodge site for construction purposes. This was especially well illustrated at Rice Lake, where the animals built many houses of lotus rather than venture 30 feet for river bulrush.

LITERATURE CITED

ERRINGTON, PAUL L.

1937. Drowning as a cause of mortality in muskrats. Journal of Mammalogy 18: 497–500.

1938. Reaction of muskrat populations to drouth. Ecology 20: 168–186.

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HATCHABILITY OF PHEASANT EGGS IN RELATION TO SOME KNOWN TEMPERATURES[1]

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From 1931 to 1933 the writer carried on a study of the Ring-necked Pheasant (*Phasianus colchicus torquatus*) on the Williamston Cooperative Game Management Project.[2] One important phase of the work was an intensive investigation of egg and nest losses. In 1932–33 it was found that 1.6 per cent of the eggs in successful nests failed to hatch because of infertility and unknown causes. In 1933 an attempt was made to determine what effect certain temperatures had upon fertile eggs.

In order to test the influence of extreme temperatures on the hatchability of pheasant eggs, a setting of 26 fresh-laid eggs was obtained from the State Game Farm and placed in the field-laboratory weather shelter, which housed a hygrothermograph and a maximum-and-minimum thermometer. The eggs were held in the shelter from April 13 until May 4, a period corresponding to a part of the egg-laying period in nature. The eggs and instruments were 4 feet from the ground and were exposed to great variation in weather conditions. During this period a record of the relative humidity and temperature was kept for all hours of the day and night.

During the 21 days in which the eggs were in the shelter, freezing temperatures were recorded seven times. The lowest temperature was 21°F., which occurred twice; 23°F. occurred once for a 5-hour period. The maximum temperature was 76°F. The relative humidity varied from 14 to 97 per cent.

The eggs were removed from the shelter on May 4 and incubated under a domestic hen. Only 14 of the 26 eggs proved fertile, but 13 of these 14 hatched on May 27. This test showed that pheasant eggs can undergo fairly low temperatures prior to incubation without their hatchability being affected to any great extent.

To test the matter further on a more extended scale, 500 eggs (1 day's laying) were obtained from the State Game Farm on May 6. Fifty eggs were kept in storage as a criterion, at temperatures varying from 45°F. to 68°F.

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[2] The Williamston Game Management Project was a cooperative undertaking under the supervision of H. M. Wight, School of Forestry and Conservation, University of Michigan. The Izaak Walton League of America, Michigan Department of Agriculture, the U. S. Biological Survey, Sporting Arms and Ammunition Manufacturers Institute, American Game Association, Michigan State College, University of Michigan, Williamston Progressive Hunting Club, and Michigan Department of Conservation aided. Particular credit goes to Harry F. Harper for his whole-hearted moral and substantial financial backing. The data presented in this paper are taken from the unpublished doctoral thesis entitled "Causes of Pheasant Mortality in Michigan" by P. F. English, University of Michigan, 1933.

TABLE 1

HATCHABILITY OF PHEASANT EGGS EXPOSED TO A TEMPERATURE OF 10°F.

Lot No.	Exposure — Dates and length			Hours	Eggs	Per cent of fertile eggs hatched
1	5/6/33—1½ hrs.			1½	30	83
2	5/6/33—1½ hrs.	5/8/33—2 hrs.		3½	30	89
3	5/6/33—1½ hrs.	5/8/33—2 hrs.	5/10/33—2 hrs.	5½	30	83

The remainder was divided into 15 lots and exposed to the following temperatures: 10°F., 16°F., 31°F., 68°F., and 85°F. Some of the eggs were given one, some two, and others three, exposures at these temperatures. Each lot, except the standard lot, consisted of 30 eggs: thus 90 eggs were exposed to each of the temperatures. When the eggs were not being subjected to the various temperatures, they were held in a basement with the standard lot. The eggs were turned every other day. They were all marked so that they could be checked with accuracy after hatching.

Arrangements were made at the State Game Farm for the use of setting coops and hens. Twenty eggs were placed under each hen on May 22 and then were so mixed that each hen had some of the eggs from each temperature-exposure class. Thus variations in the efficiency of individual hens did not affect the results.

Of the 500 eggs placed under hens, 360 hatched; of those that did not hatch, 55 were fertile and 85 were infertile: thus 83 per cent of all the eggs were fertile. Eighty-two per cent of the fertile eggs in the standard lot hatched, and 86.6 per cent of the fertile eggs in the experimental lots hatched.

From the data summarized in Tables 1 to 5 it can be seen that hatchability

TABLE 2

HATCHABILITY OF PHEASANT EGGS EXPOSED TO A TEMPERATURE OF 16°F.

Lot No.	Exposure — Dates and length			Hours	Eggs	Per cent of fertile eggs hatched
4	5/13/33—1 hr.			1	30	93
5	5/13/33—1 hr.	5/15/33—1 hr.		2	30	83
6	5/13/33—1 hr.	5/15/33—1 hr.	5/17/33—1 hr.	3	30	87

TABLE 3

HATCHABILITY OF PHEASANT EGGS EXPOSED TO A TEMPERATURE OF 31°F.

Lot No.	Exposure — Dates and length			Hours	Eggs	Per cent of fertile eggs hatched
7	5/13/33—1 hr.			1	30	82
8	5/13/33—1 hr.	5/15/33—1 hr.		2	30	92
9	5/13/33—1 hr.	5/15/33—1 hr.	5/17/33—1 hr.	3	30	92

TABLE 4

HATCHABILITY OF PHEASANT EGGS EXPOSED TO A TEMPERATURE OF 68°F.

Lot No.	*Exposure* — *Dates and length*			*Hours*	*Eggs*	*Per cent of fertile eggs hatched*
10	5/9/33—3 hrs.			3	30	82
11	5/9/33—3 hrs.	5/11/33—3 hrs.		6	30	93
12	5/9/33—3 hrs.	5/11/33—3 hrs.	5/13/33—3 hrs.	9	30	85

TABLE 5

HATCHABILITY OF PHEASANT EGGS EXPOSED TO A TEMPERATURE OF 85°F.

Lot No.	*Exposure* — *Dates and length*			*Hours*	*Eggs*	*Per cent of fertile eggs hatched*
13	5/6/33—3 hrs.			3	30	88
14	5/6/33—3 hrs.	5/8/33—3 hrs.		6	30	88
15	5/6/33—3 hrs.	5/8/33—3 hrs.	5/10/33—3 hrs.	9	30	79

varied only slightly in all ranges of temperature used. This indicated that under the conditions of the experiment temperature played a minor role in affecting the hatchability of pheasant eggs.

Since the extremes of temperature to which the eggs in these experiments were exposed were as great as, or greater than, would normally occur in the wild prior to incubation, it appears that temperature is seldom an important cause of hatching failure.

Three thunder-and-lightning storms occurred while the eggs were being incubated, but no deleterious effects upon the eggs could be determined. Eggs at the State Game Farm during this period were normal and comparable in hatchability to those of other years when there were no thunder storms during the hatching period.

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FOOD HABITS OF THE EASTERN AND NEW ENGLAND COTTONTAILS

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Period of Investigation

Studies on the ecology and management of the New England and eastern cottontails were undertaken as one of the major projects of the Connecticut Cooperative Wildlife Research Unit[1] at the time of its establishment in October, 1935. An analysis of food habits made up one of the principal divisions of this study. Field work was begun in November, 1935, and continued through October, 1937, with supplementary experimental feeding data being accumulated in the winter of 1937–38 after the Unit had been formally discontinued in December, 1937.

The eastern cottontail (*Sylvilagus floridanus mallurus*) and the New England cottontail (*Sylvilagus transitionalis*) occupy similar habitats in the State, with the latter species appearing to favor woods, borders, shrubs, and thickets over more open areas. Goodwin ('35) was the first to record the occurrence of the eastern cottontail in Connecticut. He reported two specimens taken on Sharon Mountain in Litchfield County. The investigations (Friley, 1940) of the Cooperative Wildlife Research Unit showed that the eastern cottontail is established in all except the southeastern part of the State, and is most common in the western sections. The Connecticut River marks the dividing line between the areas where the respective species predominate. West of the river the eastern cottontail is more numerous, while east of it, over about two-thirds of the State, the New England cottontail prevails. The eastern cottontail has been expanding its range for some years, and it remains to be seen whether it will attain dominance east of the river from the foothold it now has in the northern part of the eastern third.

Results as to food of the eastern and New Engand cottontails are combined since all data indicate that the feeding habits of the two species are practically identical. In the Rockville Sanctuary areas where most of the work was done, approximately 85 per cent of the population was *mallurus*. Food habits data were collected also near the State College at Storrs and on the Lebanon game management area south of Willimantic where the New England cottontail was predominant.

Methods

Four methods were used in determining the feeding habits: (1) Direct observation of feeding rabbits, (2) inspection of feeding areas as evidenced by pellets, (3) examination of vegetation near tracks in the snow, and (4) analysis of stomach contents. Examination of feeding areas proved very productive in the fall and winter when much of the diet consisted of bark and small twigs. The characteristic incisor teeth marks were readily identified on all fresh cuttings (Pearce '37).

[1] The U. S. Biological Survey, State Board of Fisheries and Game, Connecticut State College, and American Wildlife Institute cooperating.

Rabbits subsist upon a great variety of vegetation and the list of plant materials taken includes bark, twigs, leaves, fresh fruits, buds, and flowers, as well as seeds of grasses, sedges, and rushes (Trippensee '34).

A total of 307 direct observations were made upon feeding cottontails. For the purpose of putting all observations on a comparable basis, regardless of season, the hours of the day were divided into hours before and after sunrise (up to noon) and hours before and after sunset. The distribution of the observations throughout the day is shown in Table 1 and graphically in Figure 1.

A total of 1,321 observations of all kinds was recorded for approximately 100 species of plants fed upon by cottontails. Where the nature of the plant could not be determined, the observation was not included in this report. Many notes made in the early spring were discarded because of the difficulty in field identification of immature herbage.

Observations were classified somewhat artificially into the following groups as to plants utilized: (1) Trees, (2) shrubs and vines, (3) herbaceous plants other than grasses, (4) grasses, sedges, and rushes, and (5) crops.

Table 2 summarizes the number of observations by this grouping of plants as well as by months. Averages were lower during the summer due to density of vegetation reducing visibility and also to the effect of crop cover in increasing by some 60 per cent the range available to the rabbits.

With respect to feeding habits of the cottontails, the year seems to divide naturally into three seasons, namely, winter (January, February, and March), summer (April to October), and fall (November and December). The change in feeding habits from March to April is the most pronounced of the whole year and is greatest in relation to plants of the tree, shrub, and vine groups.

TABLE 1

DISTRIBUTION OF RABBIT FEEDING OBSERVATIONS DURING THE DAY

Number of hours and time	*Number of observations*	*% of total observations*
Hours before sunrise		
0–1	10	3.3
Hours after sunrise		
0–1	29	9.4
1–2	26	8.5
2–3	38	12.4
3–4	41	13.3
4–5	11	3.6
5–6	1	0.3
6–7	1	0.3
7–8	4	1.3
Hours before sunset		
7–6	3	1.0
6–5	5	1.6
5–4	5	1.6
4–3	3	1.0
3–2	13	4.2
2–1	27	8.8
Hours after sunset		
1–0	42	13.7
0–1	39	12.7
1–2	7	2.3
2–3	2	0.7

This pronounced change coincides with the appearance of the tender green shoots of a large variety of herbaceous plants. It is immediately reflected in the size, color, and texture of the droppings. The transition from summer to winter feeding habits is more gradual and is not so readily detected from the droppings. At the time of the first heavy snow, however, rabbits are forced onto their winter diet of bark, twigs, and buds, with occasional dried herbaceous

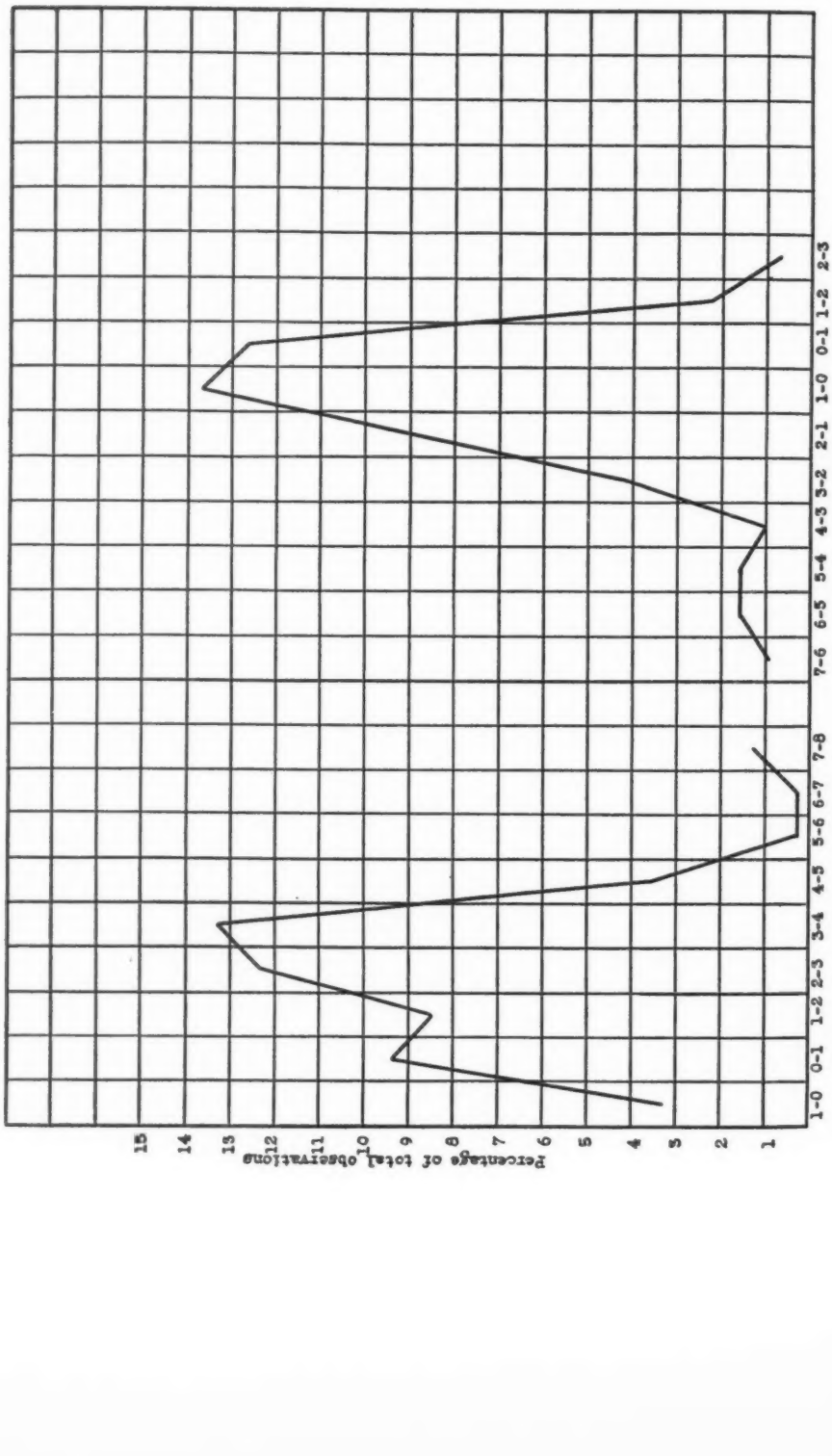

Fig. 1. Distribution of feeding observations.

TABLE 2

NUMBER OF OBSERVATIONS PER MONTH FOR EACH PLANT GROUP[1]

Month	*Trees*	*Shrubs and vines*	*Herbs*	*Grasses, sedges, rushes*	*Crops*	*Totals*
January	40(39.2)	41(40.2)	5(4.9)	6(5.9)	10(9.8)	102(100)
February	57(22.8)	149(59.6)	13(5.2)	29(11.6)	2(0.8)	250(100)
March	62(24.0)	149(57.8)	12(4.6)	28(10.9)	7(2.7)	258(100)
April	9(12.9)	3(4.3)	31(44.2)	18(25.7)	9(12.9)	70(100)
May	3(2.9)	9(8.6)	35(33.3)	39(37.1)	19(18.1)	105(100)
June	3(4.7)	1(1.6)	22(34.4)	28(43.7)	10(15.6)	64(100)
July	3(2.2)	3(2.2)	31(23.0)	75(55.6)	23(17.0)	135(100)
August	3(5.2)	1(1.7)	16(27.6)	30(51.7)	8(13.8)	58(100)
September	3(7.7)	3(7.7)	8(20.5)	20(51.3)	5(12.8)	39(100)
October	3(6.8)	12(27.3)	15(34.1)	13(29.5)	1(2.3)	44(100)
November	5(6.5)	32(41.0)	14(17.9)	14(17.9)	13(16.7)	78(100)
December	11(9.3)	32(27.1)	10(8.5)	56(47.5)	9(7.6)	118(100)
Totals and averages	202(15.3)	435(33.0)	212(16.1)	356(26.9)	116(8.7)	1321(100)

[1] Unenclosed numbers are frequency of occurrence; enclosed numbers are percentages of frequency.

stems and leaves or the green basal leaves of some perennials, including grasses. The seasonal feeding habits are summed up in Tables 3 and 5 and shown graphically in Figure 2. The data for winter food habits cover one winter of heavy snows and another of moderate severity.

WINTER FEEDING HABITS

Todd ('27) lists 73 species of shrubs and trees observed as winter food of cottontails in New York. A total of 70 kinds of trees and shrubs were recorded as fed upon by these rabbits in the present study; 14 additional species are not listed since they were involved in only random or isolated observations.

The outstanding importance of the gray birch and red maple in the winter diet of the rabbits in this area appears to be connected with their cover value inducing winter concentrations. Use of these two species was particularly no-

Fig. 1. Distribution of feeding observations.

TABLE 4

COVER TYPES ON ROCKVILLE SANCTUARY

	Cover symbol	*Acres*	*Percentage of area*	*Percentage of permanent cover*
Cultivated	Ac	282.6	60.0	—
Grass and herbs	A4	29.2	6.3	15.5
Herbs and shrubs	A4+5	11.3	2.4	5.9
Herbs and gray birch	A4+6	13.3	2.8	7.3
Gray birch	A6	17.2	3.7	9.2
Red cedar	A7	1.4	0.2	0.8
Oak-hickory	A13	16.6	3.6	8.8
Gray birch and oak-hickory	A6+13	6.2	1.4	3.4
Swamp, herbaceous	B4	72.0	15.3	38.3
Swamp, shrub	B5	0.7	0.1	0.4
Swamp, herb and shrub	B4+5	2.2	0.5	1.2
Swamp, wooded	B8	12.7	2.7	6.2
Swamp, shrub and tree	B5+8	0.9	0.1	0.5
Dump		3.1	0.6	1.6
Orchard		1.7	0.3	0.9
Totals		471	100.0	100.0

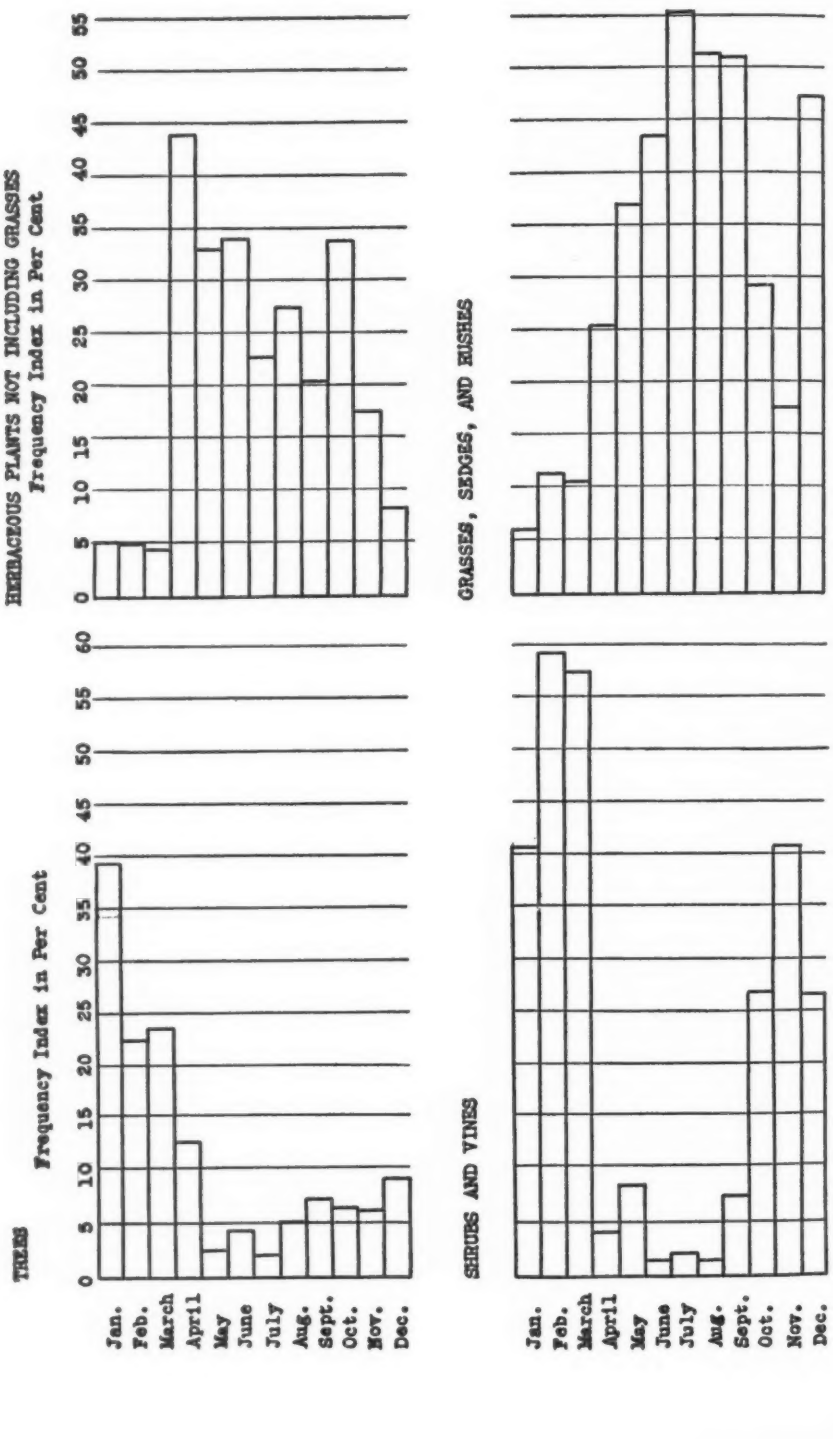
HERBACEOUS PLANTS NOT INCLUDING GRASSES
Frequency Index in Per Cent
0 5 10 15 20 25 30 35 40 45 50 55
GRASSES, SEDGES, AND RUSHES
TREES
Frequency Index in Per Cent
0 5 10 15 20 25 30 35 40 45 50 55 60
SHRUBS AND VINES
Jan. Feb. March April May June July Aug. Sept. Oct. Nov. Dec.

Fig. 2. Observations of feeding on major plant groups in terms of frequency of occurrence.

ticeable during the winter of heavy snows. Table 4 analyzes the cover types on the Rockville Sanctuary where most of the feeding observations were made; other areas investigated were similar.

Two or three species may predominate in the winter diet for a period, as where food supplies are made available by cutting in woods, opening rights-of-way through forested and shrubby areas, thinning young hardwood stands, or maintaining clearings. Pruning apple orchards also provides an abundance of twigs and bark that are readily eaten. Of all the feeding observations on shrubs and vines during the three winter months 70 per cent pertained to six species (Table 3).

Blackberry thickets not only provide rabbits with adequate retreat cover, but also form one of the most important sources of winter food. Cottontails have been observed to cut and consume entire shoots of these plants; recent growth appeared to be the most palatable. Several rabbits in a small woodlot containing a heavy stand of blackberry bushes were observed to consume, during the course of the winter, practically all of the previous season's growth.

In some localities sumac often provides a great deal of food for cottontails during the winter. In the areas studied, however, it occupied a rather minor place in the plant associations and, therefore, in the available foods. During periods of heavy snow when the movements of cottontails are greatly reduced, all of the stems in thickets of sumac may be completely girdled. However, this type of injury tends to make a clump of sumac produce suckers, resulting in spread and increase in the number of individual plants. The same result can be obtained by cutting back old growths.

Herbaceous plants seem to occupy a rather minor place in the diet of cottontails during the winter. Although rabbits were often observed to consume the stems of dried plants, identification of the species was generally impracticable.

During, January, February, and March, twenty-four observations were made of rabbits feeding on goldenrod, a plant involved in 73 per cent of all records for the period.

Grasses, sedges, and rushes were utilized twice as much as the other herbaceous plants. No attempt was made to determine species in this group as in most cases only a portion of the culm or a few blades remained.

Common rush (*Juncus effusus*) was the food concerned in 37 of 63, or 59 per cent of all the winter observations on this group of plants. Its greatest utilization was noted on the Rockville Sanctuary, where it was an abundant plant in wet meadows. Grasses were concerned in 33 per cent, and sedges in 8 per cent, of the winter feeding records.

Observations on utilization of crops during the winter related to winter rye and wheat and made up only three per cent of the total for the period. Corn fields provide little food for rabbits or other wildlife for the reasons that approximately 72 per cent of the corn raised in Connecticut is cut for silage (Davis '36), and the 18 per cent raised for grain is scattered over so large an area that the few ears remaining in the field after harvest do not provide an appreciable source of food. In fact, only one observation of cottontails feeding on corn was recorded for the entire winter.

Fig. 2. Observations of feeding on major plant groups in terms of frequency of occurrence.

TABLE 3

PLANTS FOUND TO BE UTILIZED BY COTTONTAILS, BASED ON FEEDING OBSERVATIONS[1]

Plant species	*Winter (Jan., Feb., March)*	*Summer (April–October)*
TREES[2]		
Gray birch (Betula populifolia)	47 (27.6)	4 (14.8)
Red maple (Acer rubrum)	42 (24.7)	4 (14.8)
Apple (Malus)	12 (7.1)	4 (14.8)
Aspen (Populus tremuloides)	12 (7.1)	1 (3.7)
Choke cherry (Prunus virginiana)	12 (7.1)	3 (11.1)
Wild black cherry (Prunus serotina)	12 (7.0)	3 (11.1)
White Pine (Pinus strobus)	7 (4.1)	
White oak (Quercus alba)	7 (4.1)	2 (7.4)
Bear oak (Quercus ilicifolia)	5 (2.9)	
Black oak (Quercus velutina)	3 (1.8)	
Shagbark hickory (Carya ovata)	3 (1.8)	
Yellow birch (Betula lutea)	2 (1.2)	
Box-elder (Acer negundo)	2 (1.2)	2 (7.4)
American elm (Ulmus americana)	2 (1.2)	
Red oak (Quercus borealis)	1 (0.6)	
Ironwood (Ostrya virginiana)	1 (0.6)	
Chestnut (Castanea dentata)		1 (3.7)
Black birch (Betula nigra)		1 (3.7)
Hawthorn (Crataegus)		1 (3.7)
Pear (Pyrus communis)		1 (3.7)
SHRUBS AND VINES[3]		
Blackberry (Rubus allegheniensis)	52 (15.6)	13 (40.6)
Dewberry (Rubus villosus)	49 (14.7)	
Willow (Salix)	35 (10.5)	3 (9.3)
Black alder (Ilex verticillata)	34 (10.2)	1 (3.1)
Maleberry (Lyonia ligustrina)	34 (10.2)	1 (3.1)
Highbush blueberry (Vaccinium corymbosum)	31 (9.3)	4 (12.5)
Lowbush blueberry (Vaccinium pennsylvanicum)	19 (5.6)	1 (3.1)
Silky dogwood (Cornus amomum)	16 (4.8)	
Swamp rose (Rosa)	15 (4.5)	1 (3.1)
Spiraea (Spiraea salicifolia)	14 (4.1)	2 (6.2)
Bittersweet (Celastrus scandens)	7 (2.1)	
Chokeberry (Aronia arbutifolia)	7 (2.1)	1 (3.1)
Sheep laurel (Kalmia angustifolia)	5 (1.5)	1 (3.1)
Panicled dogwood (Cornus paniculata)	4 (1.2)	
Sweet fern (Myrica asplenifolia)	3 Trace	
Sumac (Rhus glabra)	3 Trace	
Hazelnut (Corylus americana)	1 Trace	
Nannyberry (Viburnum lentago)	1 Trace	
Sassafras (Sassafras variifolium)	1 Trace	
Arrowwood (Viburnum acerifolium)	1 Trace	3 (9.3)
Serviceberry (Amelanchier canadensis)	1 Trace	
Bayberry (Myrica carolinensis)	1 Trace	
Fox grape (Vitis labrusca)		1 (3.1)
HERBS[4]		
Goldenrod (Solidago)		29 (18.4)
Plantain (Plantago lanceolata)		13 (8.2)
Chickweed (Stellaria)		11 (6.9)
Sheep sorrel (Rumex acetosella)		10 (6.3)

[1] Frequency of occurrence is given in unenclosed figures; percentage of frequency (Frequency Index) in enclosed figures. The percentage index is based on the number of times a given group of plants were taken during a given season, not on the data as a whole.

[2] During the winter 170 feeding observations were obtained; during the summer, only 27.

[3] During the winter 334 feeding observations were made; during the summer, only 32.

[4] During the summer 158 feeding observations were made.

TABLE 3—*Continued*

Plant species	*Winter (Jan., Feb., March)*	*Summer (April–October)*
Wild strawberry (Fragaria virginiana)		9 (5.7)
Smartweed (Polygonum lapathifolium)		6 (3.8)
Buttercup (Ranunculus sceleratus)		5 (3.2)
Cinquefoil (Pontentilla)		5 (3.2)
Violet (Viola)		4 (2.5)
Wood sorrel (Oxalis)		3 (1.9)
Moss		3 (1.9)
Ragweed (Ambrosia artemisiifolia)		3 (1.9)
Bur marigold (Bidens)		3 (1.9)
Dandelion (Taraxacum)		3 (1.9)
Pussytoes (Antennaria plantaginifolia)		2 Trace
Leguminosae		1 Trace
White vervain (Verbena urticaefolia)		1 Trace
Carpet weed (Mollugo verticillata)		1 Trace
Loosestrife (Lysimachia quadrifolia)		1 Trace
Ground pine (Lycopodium)		1 Trace
Wintergreen (Pyrola)		1 Trace
Mustard (Brassica)		1 Trace
Aster (Aster)		1 Trace
Bluets (Houstonia caerulea)		1 Trace
Cowslip (Caltha palustris)		1 Trace
Cranberry (Vaccinium oxycoccus)		1 Trace
Unidentified herbaceous plants		36 (22.7)

SUMMER FEEDING HABITS

The period from April through October has been included in the summer calculations of feeding observations. Tree species were of relatively minor importance as food producers during this period. Twenty-seven observations of rabbits using parts of trees representing 12 species were recorded, comprising 5.2 per cent of all the summer records.

Because of the dense herbaceous ground cover, utilization of the tree foods, especially the leaves of sprouts, could not be adequately ascertained. Stomach analysis seemed to indicate, however, only sparing use of the leaves of trees at this season.

The use of shrubs and vines during the April to October period is comparable to that of trees; thirty-two observations on 12 species comprised 6.2 per cent of all summer observations (Table 3). During this season the leaves and fruits of trees, shrubs, and vines rather than the bark, buds, and twigs, were eaten.

Summer observations indicated that a large variety of herbaceous plants were utilized, but in about 23 per cent of the whole number the young green shoots could not be accurately identified. One hundred and fifty-eight direct feeding observations were made on 26 species of herbaceous plants comprising 31 per cent of the summer total (Table 3).

Records for grasses and sedges comprised 43 per cent of all observations during the April to October period; sedges were of no importance, there being only three records. It was possible to identify the genus or species in only about 26 per cent of all observation on grasses; those determined were: Crab grass (*Digitaria sanguinalis*), *Panicum capillare*, *Panicum scoparium*, barnyard grass (*Echinochloa crus-galli*), yellow bristle-grass (*Setaria lutescens*), redtop

TABLE 5

RESULTS OF ANALYSIS OF STOMACH CONTENTS OF 75 CONNECTICUT COTTONTAILS

No. of stomachs	*April 7* %	*May 6* %	*June 16* %	*July 18* %	*Aug. 15* %	*Sept. 10* %	*Oct. 8* %
Poaceae	53.27	44.16	43.00	13.33	33.3	30.7	41.66
Trifolium	30.71	2.50	7.81	12.22		9.7	
Rosaceae	5.00	3.33		6.50	1.7		
Undetermined herbage	10.42	27.50	21.69	14.50	8.0	26.6	23.33
Undetermined seeds	0.60						
Poa		15.84	6.57				
Sheep sorrel (Rumex acetosella)		4.16	9.06	7.55	1.7		
Buttercup (Ranunculus)		1.67	2.81	.56			
Undetermined leaves		.84					
Alsine media			4.38				
Wild strawberry (Fragaria)			4.06				
Antennaria			.31			2.0	
Alopecurus aequalis			.31				
Leguminosae				15.00			
Crab grass (Digitaria sanguinalis)				14.44	12.7	19.8	
Vaccinium				5.56			
Undetermined twigs				5.00			
Agrostis				3.61	0.5		
Maple (Acer)				.56			
Carpet weed (Mollugo verticillata)				.56			
Prunus				.27	0.1	0.5	1.66
Panicum				.27	0.1		
Rubus				.05	0.1		
Plantain (Plantago lanceolata)					11.7		
Pear (Pyrus communis)					6.9		
Compositae					6.1	2.0	Trace
Undetermined stems and buds					2.0		
Mushroom					1.0		
Smartweed (Polygonum)					0.9	0.1	
Fruit skins and vegetable matter					0.7		3.33
Apple (Malus)					0.3		11.66
Goldenrod (Solidago)					0.2		1.66
Grape (Vitis)						6.5	15.00
Setaria lutescens						1.5	
Hawthorn (Crataegus)						0.3	
Barnyard grass (Echinochloa crus-galli)						0.2	
Paspalum						0.1	
Corn (Zea mays)							1.66
Average content of the animals' own fur	5.7	3.8	2.1	1.1	Trace	Trace	18.3

(*Agrostis alba*), *Paspalum pubescens*, fowl mannagrass (*Glyceria striata*), and Kentucky blue grass (*Poa pratensis*).

On the basis of the number of observations recorded, it was difficult to determine the degree to which field crops provide green feed for rabbits. Observations on the utilization of clover, timothy, and alfalfa made up 93 per cent of all the records; of these three crops, clover was decidedly preferred.

FALL FEEDING HABITS

Food taken during the fall period of November and December is intermediate between the distinctly summer and winter diets. The kinds of plants used and the amount of feeding upon them clearly indicate the transition from the warm season dominance of herbaceous plants to the prevalence in the winter subsistence of woody perennials such as shrubs, vines, and trees. The relatively

high frequency of taking of the grasses, sedges, and rushes in December is due primarily to the number of observations of cottontails feeding on the common rush (*Juncus effusus*). A preference for this species over grasses was noted throughout the winter months. Its use is probably general throughout Connecticut, since it is widely distributed in wet pastures.

STOMACH ANALYSIS

The stomach contents of specimens collected were saved whenever possible.

TABLE 6

Number of Days	Weights (in grams) of animals			
	1	2	3	4
0	1,290	1,215	930	890
5	1,290	1,180	915	900
10	1,290	1,145	900	905
15	1,255	1,135	885	935
20	1,225	1,105	865	945
25	1,215	1,050	850	930
30	1,190	1,010	855	920
35	1,175	1,030	855	920
40	1,145	1,050	850	910
44	1,080	965	850	880
Totals				
Loss in grams	210	250	80	10
Loss (% of original body weight)	16.3	20.6	8.6	1.1

The examinations were made in the Section of Food Habits Research, Division of Wildlife Research, Bureau of Biological Survey by Leon H. Kelso. The finely divided material found in rabbit stomachs makes cottontail food habit analysis difficult; undetermined items varied from 10 to 27 per cent of individual stomach contents.

Table 5 summarizes the food habits for the April to November period as revealed by analysis of the food in 75 stomachs. Results are expressed on a percentage basis, by volume, of all items for each month. For the period concerned, grasses averaged 44 per cent of all the food—a result harmonizing very well with slight records of summer feeding on grasses, 43 per cent. Other herbaceous plants represent 31 per cent by bulk of the food items in the stomach analysis material, while the feeding

TABLE 7

PREFERENCES AMONG FOODS USED IN THE 1937 AND 1938 FEEDING EXPERIMENTS

Species	Ranking	
	1937	1938
Basswood (Tilia glabra)	8	1
Serviceberry (Amelanchier canadensis)	3	2
Yellow birch (Betula lutea)	5	3
Sassafras (Sassafras variifolium)	10	4
Elm (Ulmus americana)	—	5
Chestnut (Castanea dentata)	1	6
White oak (Quercus alba)	12	7
Red maple (Acer rubrum)	2	8
Hawthorn (Crataegus)	6	9
Ironwood (Ostrya virginiana)	9	10
Sugar maple (Acer saccharum)	11	11
Highbush huckleberry (Vaccinium corymbosum)	14	12
Red pine (Pinus resinosa)	—	13
Arrow wood (Viburnum acerifolium)	—	14
White pine (Pinus strobus)	—	15
Beech (Fagus grandifolia)	7	16
Ground juniper (Juniperus communis depressa)	—	17
Panicled dogwood (Cornus paniculata)	—	18
Gray birch (Betula populifolia)	—	19
Bayberry (Myrica carolinensis)	—	20
Spicebush (Benzoin aestivale)	15	21
Mountain laurel (Kalmia latifolia)	—	22
Elderberry (Sambucus canadensis)	—	23
Red oak (Quercus rubra)	4	—
Wild black cherry (Prunus serotina)	16	—
Tag alder (Alnus rugosa)	17	—
Maleberry (Lyonia ligustrina)	18	—
Shagbark hickory (Carya ovata)	19	—
Aspen (Populus tremuloides)	20	—
White ash (Fraxinus americana)	21	—
Willow (Salix)	22	—
Sumac (Rhus glabra)	23	—
Spiraea (Spiraea tomentosa)	24	—

observations for the summer period indicated that in frequency 35 per cent of the food taken was from this group.

WINTER FEEDING EXPERIMENT

In an experimental study of preferences during February and March in 1937 and 1938, four captive animals were fed twigs from vigorous young sprouts or stems of trees and shrubs. Twenty-four species of woody plants were used in three groups of eight each. In the 1938 tests, the highest ranking 15 plants used in 1937 were again tested as were also nine additional species (Table 7). The rabbits were kept in pens 6′ × 6′ × 10′ in dimensions, with underground dens of tile. Each group of plants was fed for a period of two weeks and each species was given a rating in proportion to the quantity used by the rabbits daily. Two samples of each food were weighed, and one placed inside the pen, the other outside. Thus it was possible to ascertain increase or decrease in weight of unused food due to change in moisture content. The check samples were sheltered from rain or snow only to the same extent as the food in the pens.

At the close of the feeding tests, which were conducted for 44 days, the rabbits had lost 10, 80, 210, and 250 grams or 1.1, 8.6, 16.3, and 20.6 per cent, respectively, of their original body weights. The diet of bark, twigs, and buds alone proved insufficient to maintain the cottontails in good condition.

In Table 6 are recorded the weights of the experimental animals at five-day intervals.

During the feeding experiment, daily records were kept of the number and weights of pellets from each rabbit in addition to the weights of the food consumed. Table 8 gives a comparison of the records of the four experimental animals as to food consumption and numbers of pellets produced with a correlation determination of the number of pellets and the daily consumption of food. The average number of pellets daily and daily food consumption was determined on the basis of 30 consecutive days of experimental feeding. The standard error was computed not only for the average number of pellets for each of the four experimental animals, but also for the average amount of food eaten. At the time the feeding trials were being carried on, samples of the bark of the species used were analyzed for protein, fat, carbohydrate, moisture, and mineral, content. Table 9 gives the values determined for the various species.

TABLE 8

ANIMAL NUMBER

	1	*2*	*3*	*4*
Average number of pellets	457.6 ± 19.6[1]	505.6 ± 26.4	496.9 ± 17.8	514.1 ± 17.1
Average amount of food eaten	236.0 ± 9.6 gms.	240.4 ± 7.1 gms.	219.3 ± 8.8 gms.	252.5 ± 8.9 gms.
Coefficient of correlation	.45	.43	.63	.53

[1] Standard error.

SUMMARY

Observations on cottontails during daylight hours showed two pronounced

TABLE 9

CHEMICAL ANALYSIS OF THE BARK OF WOODY PLANTS EATEN BY RABBITS[1]

Species	*Moisture*	*Ash*	*Crude protein*	*Crude fiber*	*Nitrogen-free extract*	*Fat*
Chestnut (Castanea dentata)	6.65	1.76	4.75	28.58	54.61	3.65
Red maple (Acer rubrum)	6.20	4.34	6.25	22.15	54.86	6.20 (not all fat)
Shadbush (Amelanchier canadensis)	6.43	2.60	4.81	12.08	71.15	2.93
Red oak (Quercus borealis)	5.70	3.95	5.63	30.75	51.52	2.45
Yellow birch (Betula lutea)	5.40	2.52	9.00	25.33	54.37	3.38
Hawthorn (Crataegus)	5.78	5.84	5.63	20.68	57.39	4.68
American beech (Fagus americana)	5.83	4.24	8.25	29.70	49.13	2.85
Basswood (Tilia)	7.23	3.04	5.13	35.20	47.30	2.10
Ironwood (Ostrya virginiana)	6.20	5.20	6.06	20.10	58.72	3.68
Sassafras (Sassafras variifolium)	6.25	1.24	6.31	32.88	49.94	3.38
Sugar maple (Acer saccharum)	6.08	4.30	4.94	30.23	52.25	2.20
White oak (Quercus alba)	6.13	3.27	6.88	22.95	58.24	2.53
Panicled dogwood (Cornus paniculata)	6.58	4.42	4.13	17.20	63.79	3.88
Highbush blueberry (Vaccinium corymbosum)	5.60	1.38	5.38	31.52	52.89	3.23
Spice bush (Benzoin aestivale)	7.05	2.88	8.25	29.38	50.44	2.00
Wild black cherry (Prunus serotina)	5.70	3.39	13.38	17.60	56.58	3.35
Tag alder (Alnus incana)	5.68	2.36	6.88	20.30	57.38	7.40
Maleberry (Lyonia ligustrina)	5.93	2.62	5.88	34.73	47.41	3.43
Shagbark hickory (Carya ovata)	6.58	2.86	4.38	29.55	54.35	2.28
Trembling aspen (Populus tremuloides)	5.85	4.66	5.75	24.48	52.36	6.90
White ash (Fraxinus americana)	6.38	2.76	4.38	30.23	53.30	2.95
Willow (Salix)	5.95	2.70	7.38	17.90	60.99	5.08
Sumac (Rhus glabra)	5.85	4.34	6.25	19.93	51.11	12.52
Hardhack (Spiraea)	6.55	2.40	5.75	33.38	48.44	3.48

[1] Analyses by E. M. Bailey, Connecticut Agric. Exp. Sta., New Haven, Conn. April 1937.

feeding periods: the first, three to four hours after sunrise; and the second from sunset to one hour after.

The feeding habits follow closely availability of plants as they develop from early spring to late fall. The diet during the winter months is largely bark, twigs, buds, and dried herbs. In spring the feeding habits charge abruptly with the appearance of tender young shoots of herbaceous plants; herbs are largely used from that time through October.

In the fall period of November and December comes the transition from a diet of herbaceous plants to one of woody perennials.

In captivity, rations of twigs, bark, and buds over a period of a month during two winters proved to be inadequate to maintain body weight. Of the 24 plants tested in these experiments, chestnut, basswood, serviceberry, yellow birch, sassafras, red maple, hawthorn, ironwood, elm, and red oak proved to be the most palatable.

Analyses of the contents of 75 stomachs collected from April through October showed that grasses compose nearly half, and other herbaceous plants 31%, of the food. All herbs together formed 75% of the summer diet.

BIBLIOGRAPHY

BIRD, R. B.
1930. Cottontail Rabbits are Insectivorous. Journ. Mammalogy, 11 (2), p. 240.

DALKE, PAUL D.
1937. The cover Map in Wildlife Management. Journ. Wildlife Management, 1 (3–4), pp. 100–105.

DALKE, PAUL D. AND P. R. SIME.
1938. Home and Seasonal Ranges of the Eastern Cottontail (*Sylvilagus floridanus mallurus*) in Connecticut. Trans. Third North American Wildlife Conference, pp. 659–669.

DAVIS, I. G.
1936. Types of Farming and Types of Farming Areas in Connecticut. Storrs Agri. Exp. Sta. Bul. 213. Conn. State College, p. 120.

FRILEY, CHARLES E.
1938. The Habitat Requirements of Rabbits. Master's degree thesis, Conn. State College. Unpublished.
1940. Identification and Distribution of the Cottontail Rabbits in Connecticut. Unpublished manuscript.

GOODWIN, GEORGE GILBERT.
1935. The Mammals of Connecticut. State Geol. and Nat. History Survey Bul. 53, pp. 163–165.

LANTZ, D. E.
1916. Cottontail Rabbits in Relation to Trees and Farm Crops. U.S.D.A. Farmers' Bul. 702.

NELSON, E. W.
1909. The Rabbits of North America. North American Fauna No. 29. U.S.D.A., Bureau of Biological Survey.

PEARCE, JOHN.
1937. The Effect of Deer Browsing on Certain Western Adirondack Forest Types. Roosevelt Wildlife Bul. 53, pp. 163–165.

SETON, E. T.
1929. Lives of Game Animals. Vol. 4, Part 2, pp. 789–793.

TODD, JOHN B.
1927. Winter Food of Cottontail Rabbits. Journ. Mammalogy, 8, pp. 222–228.

TRIPPENSEE, R. E.
1934. The Biology and Management of the Cottontail Rabbit. Univ. of Mich. pp. 48–58. Unpublished Ph.D. thesis.

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OBITUARY

William Claude Kelley, Area Biologist, Soil Conservation Service, Jackson, Mississippi, member of The Wildlife Society, died July 3, 1940. His death resulted from after effects of a childhood attack of rheumatic fever. At the time of his death he was engaged in a study of bob-white foods of southern Mississippi. He had probably amassed one of the largest single-season collections of quail crops ever assembled in the United States. He had brought together, through the cooperation of state game officials and other friends, during the 1939–40 hunting season, a total of 1,171 crops from 42 counties. It was his aim to apply the wealth of data obtainable from these to farming problems connected with erosion control and wildlife conservation in his section.

During his employment with the Soil Conservation Service, Mr. Kelley also served as Junior Biologist in South Carolina and as Assistant Chief, Regional Biology Division, Southeastern Region. During these periods he contributed much to two fields of wildlife conservation as related to erosion control: (1) The educational aspect, and (2) the experimental determination of suitable plants for combined erosion-control-wildlife-conservation work. Because of his past experience as a teacher of high school students, he was constantly alive to the need for constructive training of young people in sound conservation principles and attitudes. Consequently he answered every request from 4-H club directors, school teachers, and service clubs with the best of his knowledge and efforts. He wrote numerous news articles and prepared and delivered a number of radio programs along this line. His experimental work at the Thorsby, Alabama Soil Conservation Nursery contributed greatly to the simplicity and soundness of that service's wildlife program in the Southeast. He also instigated there a series of plant succession plots which will contribute further information to the wildlife management field.

He was born March 12, 1909 in Abbeville, Alabama, son of Mr. and Mrs. T. A. Kelley. He received the B.S. degree from the Alabama Polytechnic Institute in 1930; and that of M.S. from the same institution in 1935. He was an instructor at the Alabama Polytechnic Institute in 1930–31 from where he went to head the science department of the Troy, Alabama high school until the spring of 1935. He served as head of the science department of the Tallassee, Alabama high school until his employment by the Soil Conservation Service on December 26, 1935. He resigned from that Service in November of 1936 to return to teaching, serving as science department head of the Tuskegee, Alabama high school until he reentered the Service on May 10, 1937 as Assistant Chief, Regional Biology Division. He transferred to the Jackson, Mississippi area office on May 1, 1939 as Area Biologist, which position he held until his death.

On July 3, 1939 he was married to Lois Townsley of Yuba City, California.

Claude Kelley's friends and associates remember him for many qualities. Three of these qualities that are invariably recalled and commented upon when those who knew him gather to-

gether: his sterling character, his dead earnestness as a conservationist, and his effervescent humor. One who had once heard his infectious laugh did not soon forget it. Because of these qualities, he inspired many conservationists, both young and old, and his contributions to the science, therefore, did not pass with him.

Mr. Kelley was a member of the following honorary and technical societies: Phi Kappa Phi, Phi Delta Pi, Wildlife Society.

J. A. Johnson.

NOTE

From the beginning, THE JOURNAL OF WILDLIFE MANAGEMENT has carried on the inside back cover, as part of the information for contributors, the following remarks: "Acceptance of manuscripts for printing will be on the understanding that the material has not been published, or accepted for publication, elsewhere. Printed pages available to biological contributions are too few to justify duplicate presentations." In view of these statements, members who have seen the Transactions of the Fifth North American Wildlife Conference (published January 1941) may wonder why the Eschmeyer and Tarzwell, analysis of TVA fishing, that appeared in the January 1941 issue of our Journal was also printed in the Transactions. No sooner had the Transactions appeared, then Dr. A. H. Wiebe, Chief of the Biological Readjustment Division of the TVA, called up the Editor by long-distance phone to express regret for the happening and he later wrote to the same effect. He was of the impression that the paper had been withdrawn from the Transactions as was Mr. Tarzwell when he talked to the Editor about it at the time of the Washington conference. Probably the mishap is connected with the change, during the year, in the office of Secretary of The Wildlife Institute and no individual can be definitely held accountable for it. We still believe our rule is good, however, and trust that writers will cooperate with the Editor in preventing further contraventions.